TENNESSEE DEPARTMENT OF

ENVIRONMENT AND CONSERVATION

DOE OVERSIGHT DIVISION

ENVIRONMENTAL MONITORING REPORT

JANUARY THROUGH DECEMBER 2001

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TABLE OF CONTENTS

LIST OF ACRONYMS AND COMMON ABREVIATIONS

ASER	Annual Site Environmental Report (written by DOE)
ASTM	American Society for Testing and Materials
BCK	Bear Creek Kilometer (station location)
BFK	Brushy Fork Creek Kilometer (station location)
BJC	Bechtel Jacobs Company
BMAP	Biological Monitoring and Abatement Program
BNFL	British Nuclear Fuels Limited
BOD	Biological Oxygen Demand
BWXT	Y-12 Prime Contractor (current)
CAA	Clean Air Act
CAP	Citizens Advisory Panel (of LOC)
CCR	Consumer Confidence Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Contaminants of Concern
COD	Chemical Oxygen Demand
CPM (cpm)	Counts per Minute
CRM	Clinch River Mile
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility (at ORNL)
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOE-O	Department of Energy-Oversight Division (TDEC)
DWS	Division of Water Supply (TDEC)
E. coli	Escherichia coli
EAC	Environmental Assistance Center (TDEC)
ED1, ED2, ED3	Economic Development Parcel 1, Parcel 2, and Parcel 3
EFPC	East Fork Poplar Creek
EMC	Environmental Monitoring and Compliance (DOE-O Program)
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera (May flies, Stone flies, Caddis flies)
ERAMS	Environmental Radiation Ambient Monitoring System
ET&I	Equipment Test and Inspection
ETTP	East Tennessee Technology Park
FDA	U.S. Food and Drug Administration
FRMAC	Federal Radiation Monitoring and Assessment Center
g	Gram
GHK	Gum Hollow Branch Kilometer (station location)
GIS	Geographic Information Systems
GPS	Global Positioning System
GW	Ground Water
GWQC	Ground Water Quality Criteria
HAP	Hazardous Air Pollutant
HCK	Hinds Creek Kilometer (station location)
IBI	Index of Biotic Integrity
IC	In Compliance

LIST OF ACRONYMS AND COMMON ABREVIATIONS CONTINUED

"ISCO" Sampler	Automatic Water Sampler
IWQP	Integrated Water Quality Program
K-####	Facility at K-25 (ETTP)
K-25	Oak Ridge Gaseous Diffusion Plant (now called ETTP)
KBL	Knoxville Branch Laboratory
KEAC	Knoxville Environmental Assistance Center
l	Liter
LC_{50}	Lethal Concentration at which 50 % of Test Organisms Die
LMES	Lockheed Martin Energy Systems (past DOE Contractor)
LOC	Local Oversight Committee
LWBR	Lower Watts Bar Reservoir
MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual
MBK	Mill Branch Kilometer (station location)
MCL	Maximum Contaminant Level (for drinking water)
MDC	Minimum Detectable Concentration
MEK	Melton Branch Kilometer (station location)
µg	Microgram
mg	Milligram
MIK	Mitchell Branch Kilometer (station location)
ml	Milliliter
MMES	Martin Marietta Energy Systems (past DOE Contractor)
µmho	Micro mho (mho=1/ohm)
mR	Microroentgen
mrem	1/1000 of a rem – millirem
N, S, E, W	North, South, East, West
NAAQS	National Ambient Air Quality Standards
NAREL	National Air and Radiation Environmental Laboratory
NAT	No Acute Toxicity
NEPA	National Environmental Policy Act
NIC	Not In Compliance
NOAEC	No Observable Adverse Effect Concentration (to Tested Organisms)
NOV	Notice of Violation
NPDES	National Pollution Discharge Elimination System
NRWTF	Non-Radiological Waste Treatment Facility (at ORNL)
OMI	Operations Management International (runs utilities at ETTP under CROET)
OREIS	Oak Ridge Environmental Information System **www-oreis.bechteljacobs.org/oreis/help/oreishome.html**
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Association
OSL	Optically Stimulated Luminescent (Dosimeter)
OU	Operable Unit
PACE	Paper, Allied-Industrial, Chemical, and Energy Workers Union
PAM	Perimeter Air Monitor

LIST OF ACRONYMS AND COMMON ABREVIATIONS CONTINUED

PCB	Polychlorinated Biphenol
pCi	$1x10^{-12}$ Curie (Picocurie)
PCM	Poplar Creek Mile (station location)
pH	Proportion of Hydrogen Ions (acid vs. base)
ppb	Parts per Billion
ppm	Parts per Million
ppt	Parts per Trillion
PRG	Preliminary Remediation Goals
QA	Quality Assurance
QC	Quality Control
R	Roentgen
RBP	Rapid Bioassessment Program
RCRA	Resource Conservation and Recovery Act
REM (rem)	Roentgen Equivalent Man (unit)
RER	Remediation Effectiveness Report
ROD	Record of Decision
SLF	Sanitary Landfill
SNS	Spallation Neutron Source
SOP	Standard Operating Procedure
SPOT	Sample Planning and Oversight Team
SS	Surface Spring
STP	Sewage Treatment Plant
SW	Surface Water
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TLD	Thermoluminescent Dosimeter
TOA	Tennessee Oversight Agreement
TRE	Toxicity Reduction Evaluation
TRM	Tennessee River Mile
TRU	Transuranic
TSCA	Toxic Substance Control Act
TSCAI	Toxic Substance Control Act Incinerator
TSS	Total Suspended Solids
TTHM's	Total Trihalomethanes
TVA	Tennessee Valley Authority
TWQC	Tennessee Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency
U.S.	United States
UT-BATTELLE	University of Tennessee-Battelle (ORNL Prime Contractor)
VOC	Volatile Organic Compound
WCK	White Oak Creek Kilometer (station location)
WM	Waste Management
WOL	White Oak Lake
X-####	Facility at X-10 (ORNL)
X-10	Oak Ridge National Laboratory
Y-####	Facility at Y-12
Y-12	Y-12 Plant (Area Office)

EXECUTIVE SUMMARY

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) is providing a report of its independent environmental monitoring for the calendar year 2001. The report is a series of individual reports completed by division personnel. The reports are organized by general areas of interest: Surface Water; Sediment; Drinking Water; Biological/Fish and Wildlife; Groundwater; Air Quality and Radiation. An abstract is provided in each report. All supporting information and data used in the completion of these reports are available for review in the division's files.

Surface Water

The surface water sampling is an attempt to assess the environmental impact and quality of rivers, streams, lakes and impoundments around the Oak Ridge Reservation (ORR). Surface water samples for physical and chemical parameters were collected at 23 locations and compared against the Tennessee Water Quality Criteria (TWQC) standards. None of the sampled sites exceeded the TWQC criteria for recreation. The surface water seems to be relatively healthy for its classified uses indicating that the drinking water sources pose no apparent health risks from contamination.

Sediment

Sediment sampling showed no levels of concern for the contaminants sampled. Mercury concentrations in samples taken in the Clinch River below the confluence of Poplar Creek are elevated but are still below Department of Energy's (DOE) Preliminary Remediation Goals (PRG). Further investigations for sediment mercury are expanded in 2002 to include two sampling sites at the Tennessee River.

Drinking Water

The monitoring activities through oversight and independent sampling of the sanitary water distribution systems on the ORR met the regulatory requirement of 0.2 mg/L for residual chlorine. No elevated levels of bacteria above the regulatory limits were reported. The Environmental Radiation Ambient Monitoring System (ERAMS) indicate that radionuclides are well below regulatory criteria. However, tritium has been consistently higher for the Gallaher water treatment plant than the four other systems monitored in the program.

Biological, Fish and Wildlife

Diatom and benthic macroinvertebrate samples were collected from twelve study sites located on five streams: East Fork Poplar Creek, Bear Creek, White Oak Creek, Melton Branch, and Mitchell Branch. Sampling results indicate that streams exhibit signs of increasing water quality with distance downstream of DOE influences. However, the number of sensitive species and the total number of species at the study sites continue to be depressed compared to their respective reference locations.

During the 2001 sampling, 232 Canada Geese were captured and tested for radiological contamination. None of the birds analyzed had levels of gamma radionuclides above the 5pCi/g game release level.

Groundwater

The results of residential wells sampled showed no discernible impact from the activities of DOE on the ORR. The well samples were analyzed for volatile organic compounds, nutrients, radiochemistry, general chemistry, and selected metals. The general groundwater quality of the eleven residential wells appears to be acceptable. The data indicate that sample concentrations are in a range that could be considered background water quality. The independent sampling of springs and seeps on the ORR provided indication of movement of contaminants in the subsurface and in the groundwater. Springs in Bear Creek valley down gradient from the Bear Creek burial grounds continue to be impacted by radiochemical, metal and volatile organic constituents.

A hydrogeologic investigation of SS-5 (a spring) to determine groundwater flow from Chestnut Ridge and Bear Creek valley was conducted to improve monitoring for the Spallation Neutron Source facility and Y-12. The groundwater tracing evidenced a connection between the Chestnut Ridge hydrogeologic regimes and that of Bear Creek at SS-5.

Air Quality

ERAMs gamma annual analyses were unavailable for this report. However, the analyses for gross alpha and gross beta did not indicate a significant impact on local air quality from activities on the ORR. As well, the ERAMS data mirrored trends obtained from the results of the perimeter and fugitive air monitoring program, indicating no significant impact on the local air quality attributable to DOE activities on the ORR. The fugitive radiological air emission results at sites of interest were consistently higher than background measurements but below Clean Air Act standards.

The Hazardous Air Pollutants (HAPs) for metal monitoring at Y-12 and Oak Ridge National Laboratory (ORNL) indicated no apparent elevated levels of the metals of concern. HAPs metals monitored were arsenic, beryllium, cadmium, total chromium, lead, nickel and uranium metal.

Radiation

All doses reported for 2001 at off-site locations were below the state primary dose limit for members of the public. However, some locations associated with the uranium hexafluoride cylinder storage yard at East Tennessee Technology Park (ETTP) that are potentially accessible to the public due to DOE re-industrialization efforts, have doses in excess of the state/DOE primary dose limits for members of the public.

Maintenance of DOE boundaries and fences is very essential and important to prevent public exposure. The real time ambient gamma monitoring of four sites on the ORR, (the 3513 Waste Holding Basin, Corehole 8 remedial action, the Molten Salt reactor and the K-33 process building) showed the highest result of 324μR/hr at the Corehole 8 remedial action site. The ambient gamma radiological screening of the sediments of Poplar Creek from its confluence with Clinch River upstream to the mouth of East Fork Poplar Creek indicated no previously unidentified radioactively contaminated sites.

The footprint reduction survey focused on identifying potential anthropogenic sources of contamination and exit pathway releases on the ORR that could render portions of land unfit for release. The footprint survey investigated 21,439 acres of ORR land. The facility survey program characterizes the overall condition of building and other related facilities on the ORR for physical condition, level of contamination and the potential release of contaminants to the environment. The survey program evaluated 17 facilities and found that eight posed a high potential for environmental release. However, corrective measures by DOE have removed seven facilities from this category of high potential environmental release list.

Conclusion

The 2001 monitoring results showed continuous effort by DOE to improve the overall health of the public and the environment. DOE is moving in the right direction to treat and dispose of some legacy wastes. Buried wastes, however, pose a potential risk to the public and the environment. Therefore, it will be necessary and prudent for the state to continue its monitoring efforts to detect as early as possible, potential releases from these waste accumulation areas and burials.

INTRODUCTION

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division), in accordance with the Tennessee Oversight Agreement Attachment A.7.2.2, is providing an annual environmental monitoring report of the results of its monitoring and analysis activities during the calendar year of 2001, for public distribution. The division was established in 1991 to administer the Tennessee Oversight Agreement and the CERCLA required Federal Facility Agreement. These agreements are designed to assure the citizens of Tennessee that their health, safety, and environment are being protected through existing programs and substantial new commitments by the Department of Energy (DOE).

The division's monitoring efforts planned for 2002 are described in its 2002 Environmental Monitoring Plan as submitted to the DOE Oak Ridge Operations in January 2002. All of the environmental monitoring projects planned for 2002 were attempted by the Division except for one. The study on the Y-12 Landfill seeps and springs was not completed in full because of drought and personnel changes.

The report consists of a series of individual reports that involve independent environmental monitoring by the division. The individual reports are organized by general areas of interest: Surface Water; Drinking Water; Biological/Fish and Wildlife; Groundwater; Air Quality; and Radiation. Abstracts and conclusions are available in each report to provide a quick overview of the content and outcome of each monitoring effort. All supporting information and data used in the completion of these reports are available for review in the division's program files. Overall, the report characterizes and evaluates the chemical and radiological emissions in the air, water, and sediments both on and off the Oak Ridge Reservation.

The division has considered the location, environmental setting, history, and on-going DOE operations in its environmental monitoring programs. The information gathered provides a better understanding of the fate and transport of contaminants released from the Oak Ridge Reservation into the environment. This understanding has lead to the development of an ambient monitoring system and increased the probability of detecting releases in the event that institutional controls on the Oak Ridge Reservation fail.

Currently, the division's monitoring activities have not detected any imminent threats to public health or the environment outside of the Oak Ridge Reservation. However, unacceptable releases of contaminants from past DOE operational and disposal activities continue to pose risk to the environment and it is imperative to note that if current institutional controls fail or if the present contaminant source controls can no longer be maintained, the public would be at risk of environmental contamination.

Site Description

The DOE Oak Ridge Reservation (ORR), as shown in Figure 1, encompasses approximately 35,000 acres and three major operational DOE facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Y-12 Plant (Y-12), and the East Tennessee Technology Park (ETTP, formerly the K-25 Gaseous Diffusion Plant). The initial objectives of the ORR operations were the production of plutonium and the enrichment of uranium for nuclear weapons components. In the 56 + years since the ORR was established, a variety of production and research activities have generated numerous radioactive, hazardous, and mixed wastes. These wastes, along with wastes from other locations, were disposed of on the ORR. Early waste disposal methods on the ORR were rudimentary compared to today's standards.

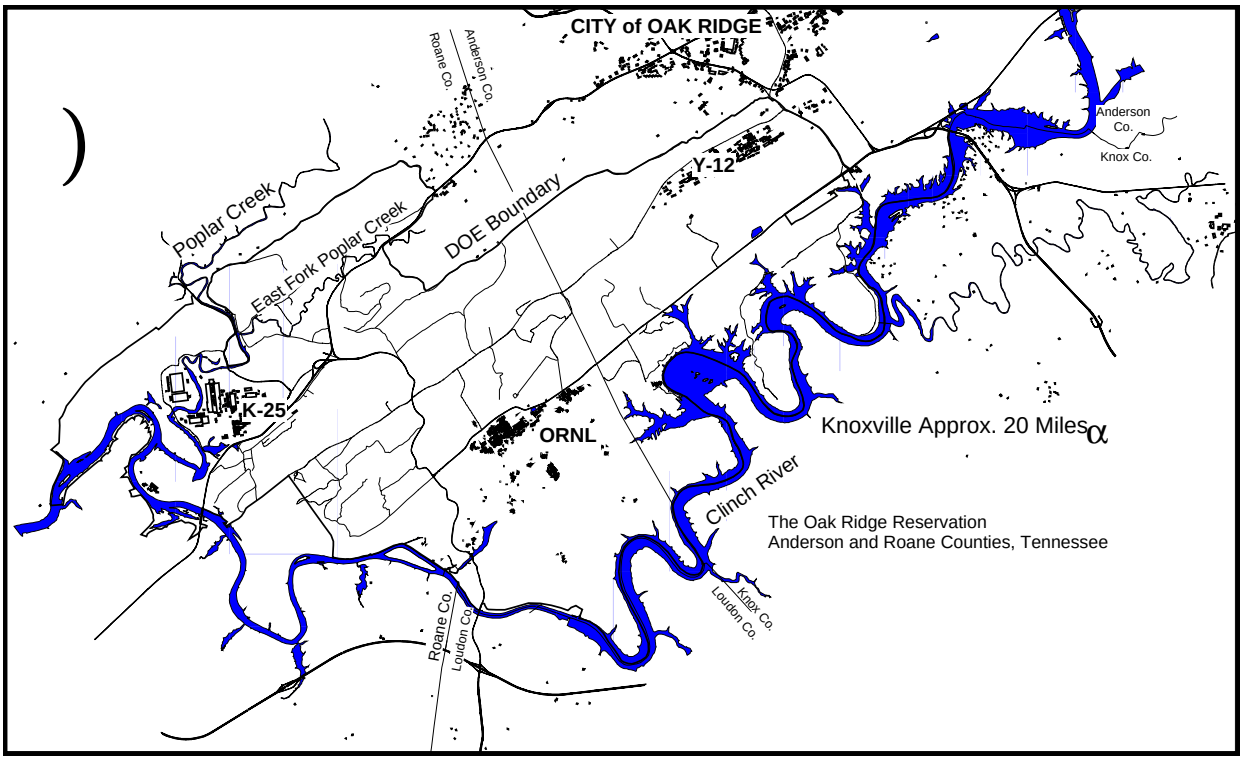

Figure 1: The Oak Ridge Reservation

The ORR is located within the corporate boundaries of the city of Oak Ridge, Tennessee, in the counties of Anderson and Roane. The Reservation is bounded on the north and east by residential areas of the city of Oak Ridge and on the south and west by the Clinch River. Counties adjacent to the Reservation include Knox, Loudon, and Morgan. Meigs and Rhea counties are immediately downstream on the Tennessee River from the ORR. The nearest cities are Oak Ridge, Oliver Springs, Kingston, Lenoir City, Harriman, Farragut, and Clinton. The nearest metropolitan area, Knoxville, lies approximately 20 miles to the east. Figure 2 depicts the general location of the Oak Ridge Reservation and nearby cities.

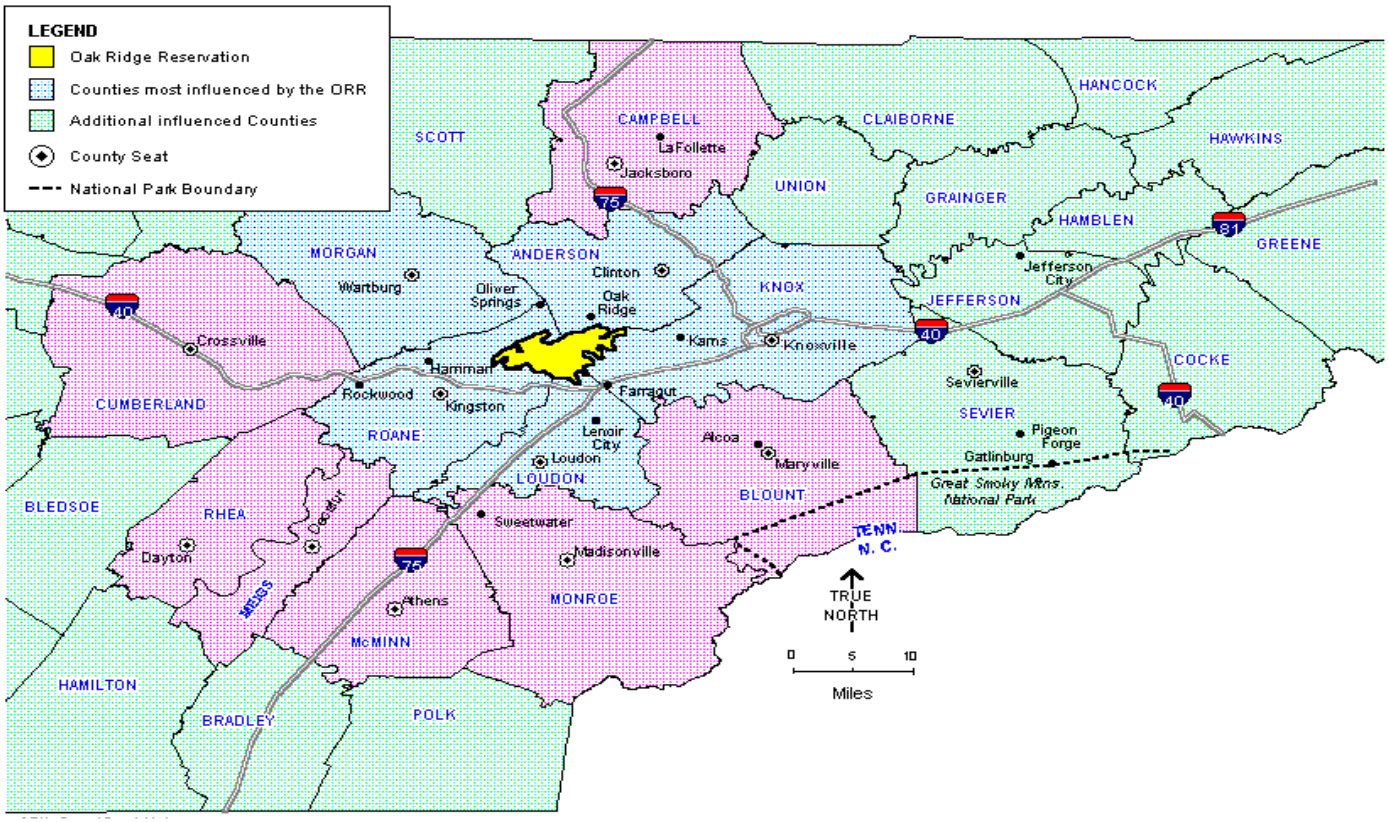

Figure 2: Location of the Oak Ridge Reservation

The ORR lies in the Valley and Ridge Physiographic Province of East Tennessee. The Valley and Ridge Province is a zone of complex geologic structures dominated by a series of thrust faults and characterized by a succession of elongated southwest-northeast trending valleys and ridges. In general, the ridges are underlain by sandstones, limestones, and/or dolomites that are relatively resistant to erosion. The valleys are underlain by weaker shales and more soluble carbonate rock units.

The hydrogeology of the ORR is very complex with a number of variables influencing the direction, quantity, and velocity of groundwater flow that may or may not be evident from surface topography. In many areas of the ORR, groundwater appears primarily to travel along short flow paths in the storm flow zone to nearby streams. In other areas, evidence indicates substantial groundwater flow and, thereby, contaminant transport may occur preferentially in fractures and solution cavities in the bedrock for relatively long distances.

As seen in Figure 3, streams on the ORR drain to the Clinch River. Melton Hill Dam impounded the Clinch River in 1963. Contaminants released on the Oak Ridge Reservation enter area streams (e.g., White Oak Creek, Bear Creek, East Fork Poplar Creek, and Poplar Creek) and are transported into the Clinch River and Watts Bar Reservoir on the Tennessee River.

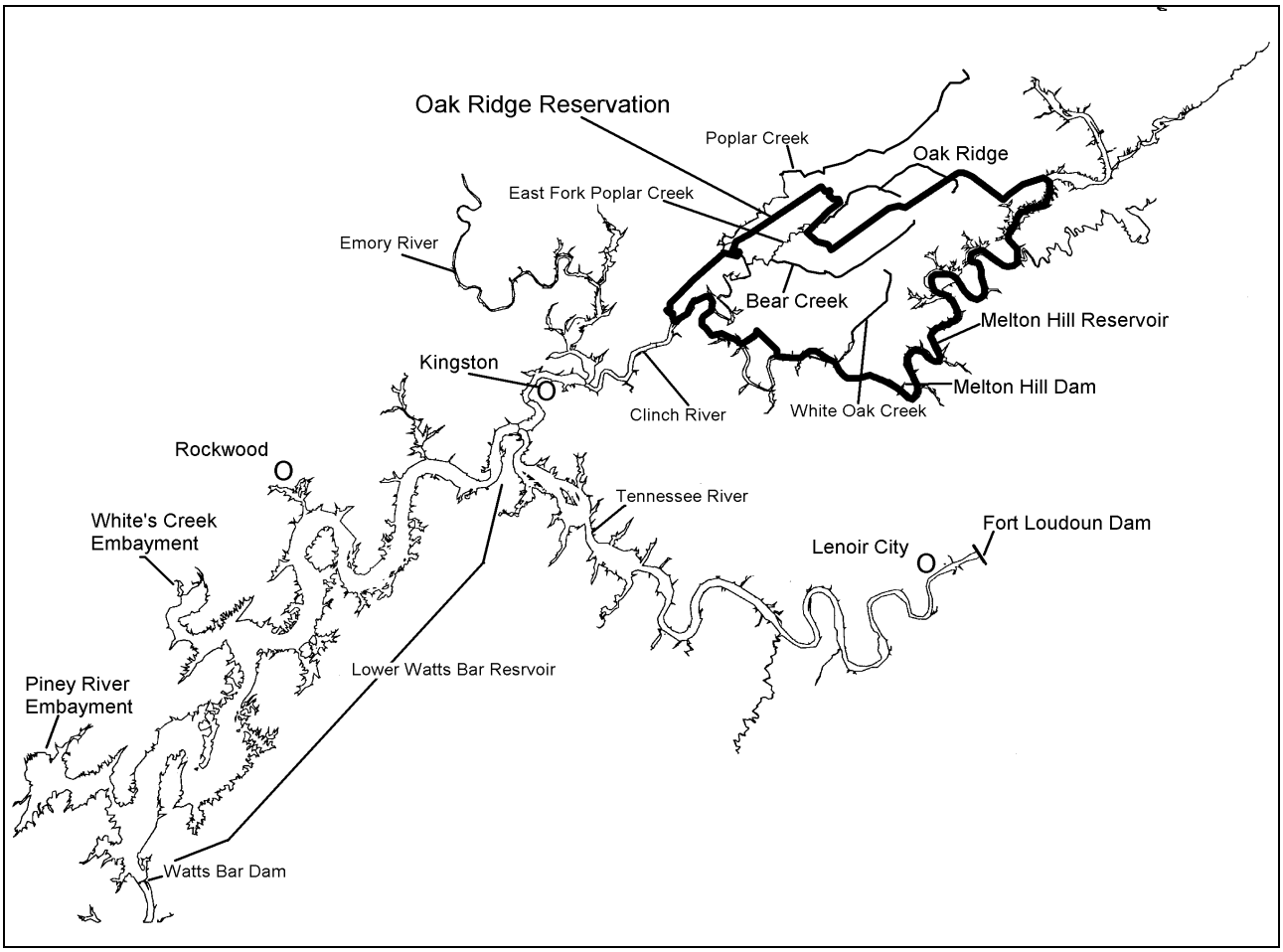

Figure 3: Watts Bar Reservoir

The climate of the region is moderately humid and the annual average precipitation is around 55 inches. Winds on the reservation are controlled, in large part, by the valley and ridge topography with prevailing winds moving up the valleys (northeasterly) during the daytime and down the valleys (southwesterly) at night.

Chapter 1 SURFACE WATER MONITORING

Ambient Surface Water Monitoring Program

Principle Author: John Peryam

Abstract

Surface water analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. The DOE Oversight Division conducted sampling at 23 sites in 2001. The samples were analyzed for standard water quality parameters. Based on comparisons with the Tennessee Water Quality Criteria (TWQC) for recreation, none of the sites exceeded these criteria.

Introduction

The Tennessee Department of Environment and Conservation's DOE Oversight Division (TDEC/DOEO) conducts an ambient surface water sampling program that monitors 25 sites. Seven sites were originally chosen for the purpose of detecting any possible contamination from DOE sites via surface water, stormwater, or groundwater. Sites 1 and 2 were chosen as background data collection sites and are located above the Oak Ridge Reservation before any impact by the three DOE sites. The original seven sampling sites on the Clinch River (sites 1 through 7) have been sampled quarterly under this program from 1993 to 1996. In 1997, fifteen sampling sites were added to the program. These newer sites are tributaries of the Clinch River located on the Oak Ridge Reservation (ORR). These sites are numbered 8 through 22 and listed in Table 1.1 and Figure 1.1. Three new sites were added in 1999. These three new sites are numbered 23 through 25; two of these are background streams (Clear Creek and White Creek) and the other unnamed stream is a tributary of the Clinch River that flows through Oak Ridge.

Chemical contamination levels in streams may fluctuate greatly due to many factors, such as dilution, concentration, intermittent sources of contaminants, absorption, chemical interactions with geological substrates, etc. The Clinch River, being large and subject to dilution, is not expected to have high concentrations of pollutants in surface water grab samples. However, the sampling data do set up a baseline for comparison to previous sampling events. In the case of an unplanned release or an accident, the sampling data may help to reflect the amount and extent of pollution.

The sampling sites were sampled twice during 2001. Samples were analyzed for each of the parameters in Table 1.2. Surface water data was compared with Tennessee Water Quality Criteria.

Table 1.1 Sample Locations:

Site	Location	Clinch River Mile	Quarter(s) Sampled
1	Downstream of Norris Dam	78.7	2,4
2	Anderson County Water Treatment Plant	52.6	2,4
3	Melton Hill Park	35.5	2,4
4	Grubb Islands	17.9	2,4
5	Brashear Island	10.1	2,4
6	Bull Run Steam Plant	48.7	2,4
7	Water Treatment Plant	41.2	2,4
8	Scarboro Creek	41.2*	2,4
9	Kerr Hollow Branch	41.2*	2,4
10	McCoy Branch	37.5*	2,4
11	Western Branch	37.5*	None**
12	East Fork of Walker Branch	33.2*	2,4
13	Bearden Creek	31.8*	2,4
14	Unnamed Stream	27.0*	None**
15	Unnamed Stream	26.6*	2,4
16	Unnamed Stream	23.0*	2,4
17	Unnamed Stream	20.0*	2,4
18	Raccoon Creek	19.5*	2,4
19	Ish Creek	19.1*	2,4
20	Grassy Creek	14.55*	2,4
21	Unnamed Stream	14.55*	2,4
22	Unnamed Stream	14.45*	2,4
23	Unnamed Stream	51.1*	2,4
24	White Creek	N.A.	2,4
25	Clear Creek	77*	2,4

*This figure is the approximate Clinch River Mile where the tributary meets the river.
**Stream was dry during one or more sampling trips.

Figure 1.1 Map of Sampling Sites (See Table 1.1)

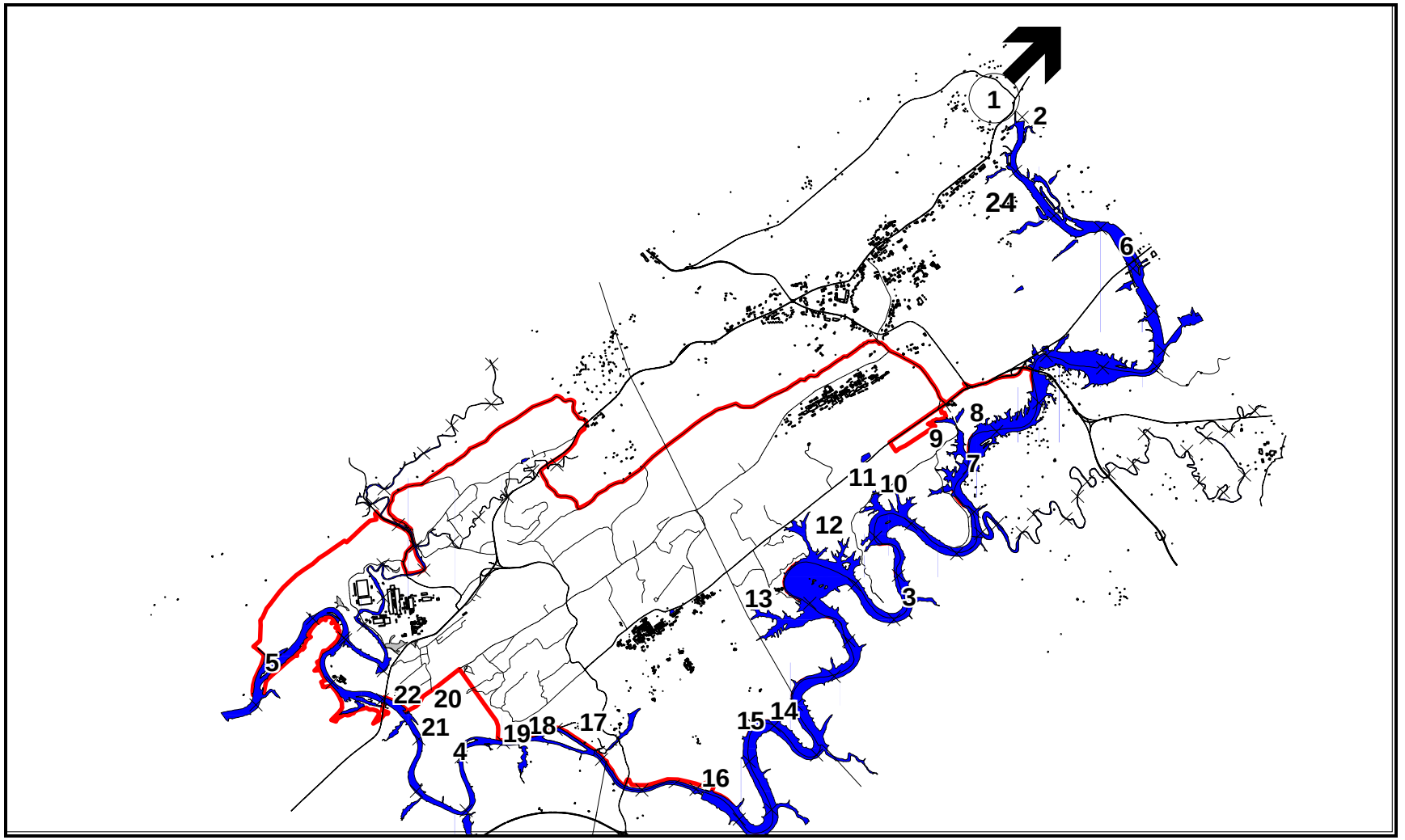

Table 1.2. Ambient water sampling parameters

Parameter	Units	Tennessee Water Quality Criteria (TWQC)*
Conductivity	umho	
Dissolved Oxygen	mg/l	5.0 (f)
pH	Units	6.5-8.5 (f)
Temperature	degrees C	<= 30.5
E. Coli	cfu/100ml	1000
Enterococcus	cfu/100 ml	
Residue - dissolved	mg/l	500 (d)
Nitrogen, NO_3 & NO_2	mg/l	
Nitrogen, ammonia	mg/l	
Residue - suspended	mg/l	
Nitrogen, total kjeldahl	mg/l	
Phosphate, total	ug/l	
Hardness, total, as $CaCO_3$	mg/l	
Arsenic, As	ug/l	1.4 (r)
Cadmium, Cd	ug/l	3.9 (f)
Chromium, Cr	ug/l	16 (f)
Copper, Cu	ug/l	17.7 (f)
Iron, Fe	ug/l	
Lead, Pb	ug/l	5 (d)
Manganese, Mn	ug/l	
Mercury, Hg	ug/l	0.14 (r)
Zinc, Zn	ug/l	117 (f)

*Tennessee Water Quality Criteria: (d)-domestic water supply, (f)-fish & aquatic life, (r)-recreation.

Sampling Sites

Site 1 – Downstream of Norris Dam: Samples are taken from the Clinch River from the bank at the first recreation access point downstream of Norris Dam. The coordinates are approximately 36º 13' 11" N latitude and 84º 05' 20" W longitude. This site is upstream of possible DOE impacts and is a reference site in this respect. It may, however, show effects of agricultural, industrial and residential activities upstream.

Site 2 - Anderson County Water Treatment Plant: Samples are taken from the Clinch River from a boat in an area approximately 20 to 40 feet from the west bank of the river, just offshore from the water treatment plant. The coordinates are approximately 36º 03' 46" N latitude and 84º 11' 49" W longitude. This site is upstream of possible DOE impacts and is a reference site in this respect. It may, however, show effects of agricultural, industrial and residential activities upstream.

Site 3 - Melton Hill Park: Samples are taken by the same methods as used at Site 2 in an area approximately 20 to 40 feet from the west bank of the river approximately one half mile downstream of the Knoxville Utility Board's pumping station. The coordinates are approximately 35º 56' 39" N latitude and 84º 14' 21" W longitude.

Site 4 - Grubb Islands: Samples are taken by the same methods as used at Site 2 in an area approximately 20 to 40 feet from the west bank of the river approximately 100 to 200 feet downstream of the larger Grubb Island. The coordinates are approximately 35º 53' 52" N latitude and 84º 22' 24" W longitude.

Site 5 - Brashear Island: Samples are taken by the same methods as used at Site 2 in an area approximately 20 to 40 feet south of the last sandbar (going downstream) of the river approximately 400 to 500 feet upstream of Brashear Island. The coordinates are approximately 35º 55' 13" N latitude and 84º 26' 02" W longitude.

Site 6 - Bull Run Steam Plant: Samples are taken by the same methods as used at Site 2 in an area approximately 20 to 40 feet of the west bank of the river at a point near the upstream end of the skimmer wall. The coordinates are approximately 36º 01' 28" N latitude and 84º 10' 02" W longitude.

Site 7 - Water Treatment Plant: Samples are taken by the same methods as used at Site 2 in an area approximately one half mile downstream of the Water Treatment Plant Intake. The coordinates are approximately 35º 58' 30" N latitude and 84º 12' 30" W longitude.

Site 8 - Scarboro Creek: Samples are taken from the creek at a point near the confluence with Melton Hill Lake. The coordinates are approximately 35º 58' 59" N latitude and 84º 13' 00" W longitude.

Site 9 - Kerr Hollow Branch: Samples are taken from the creek at a point about 50 feet from the confluence with Melton Hill Lake. The coordinates are approximately 35º 58' 45" N latitude and 84º 13' 37" W longitude.

Site 10 - McCoy Branch: Samples are taken from the creek approximately 150-200 feet upstream of the confluence with Melton Hill Lake. The coordinates are approximately 35º 57' 57" N latitude and 84º 14' 54" W longitude.

Site 11 - Western Branch: Samples are taken from the creek at a point about 150 yards from the confluence with Melton Hill Lake. The coordinates are approximately 35º 58' 00" N latitude and 84º 15' 05" W longitude.

Site 12 - East Fork of Walker Branch: Samples are taken from the creek in a length of the stream about 150 feet in distance, beginning about 100 feet from the confluence with Melton Hill Lake. The exact location depends upon the water level of the Clinch River at the time of sampling. The gradient of the stream at this point is slight and sometimes the river backs up into the stream, therefore sampling must be done farther upstream to obtain a sample representative of the stream and not the river. The coordinates are approximately 35º 57' 22" N latitude and 84º 15' 58" W longitude.

Site 13 - Bearden Creek: Samples are taken from the creek at point about 150 feet from the confluence with Melton Hill Lake. The coordinates are approximately 35º 56' 05" N latitude and 84º 17' 01" W longitude.

Site 14 – Unnamed Stream: Samples are taken from the creek at a point about 50 feet from the confluence with Melton Hill Lake. The coordinates are approximately 35º 54' 25" N latitude and 84º 16' 39" W longitude.

Site 15 – Unnamed Stream: Samples are taken from the creek at a point about 30 feet from the confluence with Melton Hill Lake. The coordinates are approximately 35º 54' 21" N latitude and 84º 17' 06" W longitude.

Site 16 – Unnamed Stream: Samples are taken from the creek at a point about 120 feet from the confluence with the Clinch River. The coordinates are approximately 35º 53' 22" N latitude and 84º 18' 04" W longitude.

Site 17 – Unnamed Stream: Samples are taken from the creek at a point about 2000 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 14" N latitude and 84º 20' 12" W longitude.

Site 18 - Raccoon Creek: Samples are taken from the creek at point about 1000 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 12" N latitude and 84º 21' 05" W longitude.

Site 19 - Ish Creek: Samples are taken from the creek at a point about 1000 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 11" N latitude and 84º 21' 33" W longitude.

Site 20 - Grassy Creek: Samples are taken from the stream at a point about one half mile from the confluence with the Clinch River. The coordinates are approximately 35º 54' 36" N latitude and 84º 22' 55" W longitude.

Site 21 – Unnamed Stream: Samples are taken from the stream at point about one half mile from the confluence with the Clinch River. This site is very close to the Grassy Creek sampling site; these two creeks come together immediately before entering the Grassy Creek embayment. The coordinates are approximately 35º 54' 36" N latitude and 84º 22' 57" W longitude.

Site 22 – Unnamed Stream: Samples are taken from the stream at the opening of the culvert that brings water from the K-1515C lagoon, approximately 100 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 29" N latitude and 84º 23' 25" W longitude.

Site 23 – Unnamed Stream: This stream is located behind Warehouse Road in Oak Ridge. Samples are taken a short distance from the Clinch River embayment at Clinch River Mile 51.1. The approximate coordinates are 36º 02' 19" N latitude and 84º 12' 47" W longitude. This site is upstream of any possible DOE impacts and is a reference site in this respect. It may, however, show effects of any agricultural, industrial and residential activities upstream.

Site 24 – White Creek: This stream is located in the Chuck Swann Wildlife Management Area in Union County. Samples are taken about 1/3 mile downstream from an old TVA water monitoring facility about one mile upstream of Norris Lake. The approximate coordinates are 36º 20' 47" N latitude and 83º 53' 42" W longitude.

Site 25 – Clear Creek: This stream is located near Norris Dam near Clinch River Mile 77. Samples are taken near a water storage facility about one mile upstream of the river. The approximate coordinates are 36º 12' 49" N latitude and 84º 03' 33" W longitude. This is a background site.

Methods and Materials

Surface water samples were taken during April, May and October using the methods described in the 2001 Ambient Surface Water Sampling Plan. The Tennessee State Laboratories processed the samples, according to EPA approved methods.

Results and Discussion

Surface water quality in the Clinch River and tributaries sampled is good. None of the parameters sampled for exceeded Tennessee Water Quality Criteria

Conclusions

Based on comparisons with Tennessee Water Quality Criteria, the water quality of the Clinch River and the tributaries sampled is good.

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Chapter 1 SURFACE WATER MONITORING

Toxicity Biomonitoring of DOE Effluent Discharges

Principal Author: Kristof Czartoryski

Abstract

As required by the National Pollutant Discharge Elimination System (NPDES) operating permits, Department of Energy (DOE) conducts routine toxicity testing of its Oak Ridge Reservation (ORR) effluents discharging to the waters of the State of Tennessee.

In 2001, during the period of April 23-27 and on June 11, the TDEC/DOE-O Division conducted an independent toxicity sampling at the following DOE locations (See maps Fig. 1& 2):

1. East Tennessee Technological Park (ETTP) - Outfall 005, K-1203 Sewage Treatment Plant,
2. Oak Ridge National Laboratory (ORNL) - Outfall X-02, Coal Yard Runoff Treatment Facility (CYRTF.)

Toxicity of DOE effluents was evaluated based on 3-Brood *Ceriodaphnia dubia* (water flea) Survival and Reproduction Test and a 7-Day *Pimaphales promelas* (fathead minnow) Larval Survival and Growth Test.

The DOE NPDES permits specify effluent concentrations for which no acute (LC_{50}) or chronic toxicity is to be attained. LC_{50} is the concentration of effluent that is lethal to 50% of the test organisms during a 96-hour period. Thus, the lower the value, the more toxic an effluent. The DOE NPDES permits specify also a No Observable Adverse Effect Concentration (NOAEC), an effluent concentrations for which there should be no observable adverse chronic effect on test organisms survival and reproduction for *Ceriodaphnia dubia*, or survival and growth for *Pimaphales promelas*.

The independent toxicity biomonitoring testing of the DOE discharges confirmed that there was no toxicity exhibited by the effluents from the ETTP Sewage Treatment Plant (STP) and ORNL Coal Yard Runoff Treatment Facility (CYRTF) and that both DOE treatment facilities complied with conditions of their NPDES permits.

Introduction

In 1998, the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight (DOE-O) Division approved a project to conduct toxicity biomonitoring tests to verify Department of Energy (DOE) adherence to National Pollution Discharge Elimination System (NPDES) operating permits. This project was conducted by the TDEC/DOE-O Division under the authority of the Tennessee Oversight Agreement and was continued in 2001.

In accordance with the NPDES permits, DOE must observe toxicity limits in its effluents discharging into the waters of the state. In addition to routine toxicity testing of final effluents, the permittee (DOE) must initiate a Toxicity Reduction Evaluation and Toxicity Identification

Evaluation (TRE/TIE) when an effluent is determined to cause a significant reduction in growth or survival of test organisms.

The TDEC/DOE-O Division conducted the independent sampling of DOE effluents discharged into waters of the state during the period of April 23-27, 2001 and on June 11, 2001. The samples of final effluent were collected from the following locations:

1. East Tennessee Technological Park (ETTP) - Outfall 005, K-1203 Sewage Treatment Plant (STP), NPDES Permit No. TN0002950,
2. Oak Ridge National Laboratory (ORNL) - Outfall X-02, Coal Yard Runoff Treatment Facility (CYRTF), NPDES Permit No. TN0002941

The results of the toxicity evaluation of DOE discharges are presented in Tables 1-4.

The scheduling of the TDEC/DOE-O Division's tests was dependent on the availability of the State Toxicological Laboratory in Nashville and, due to its reliance on the DOE 24-hour automated composite sample collection equipment, it had to be closely coordinated with DOE contractor's personnel. This accounted for the decision to drop the planned third sampling event at the Y-12 Facility.

Methods and Materials

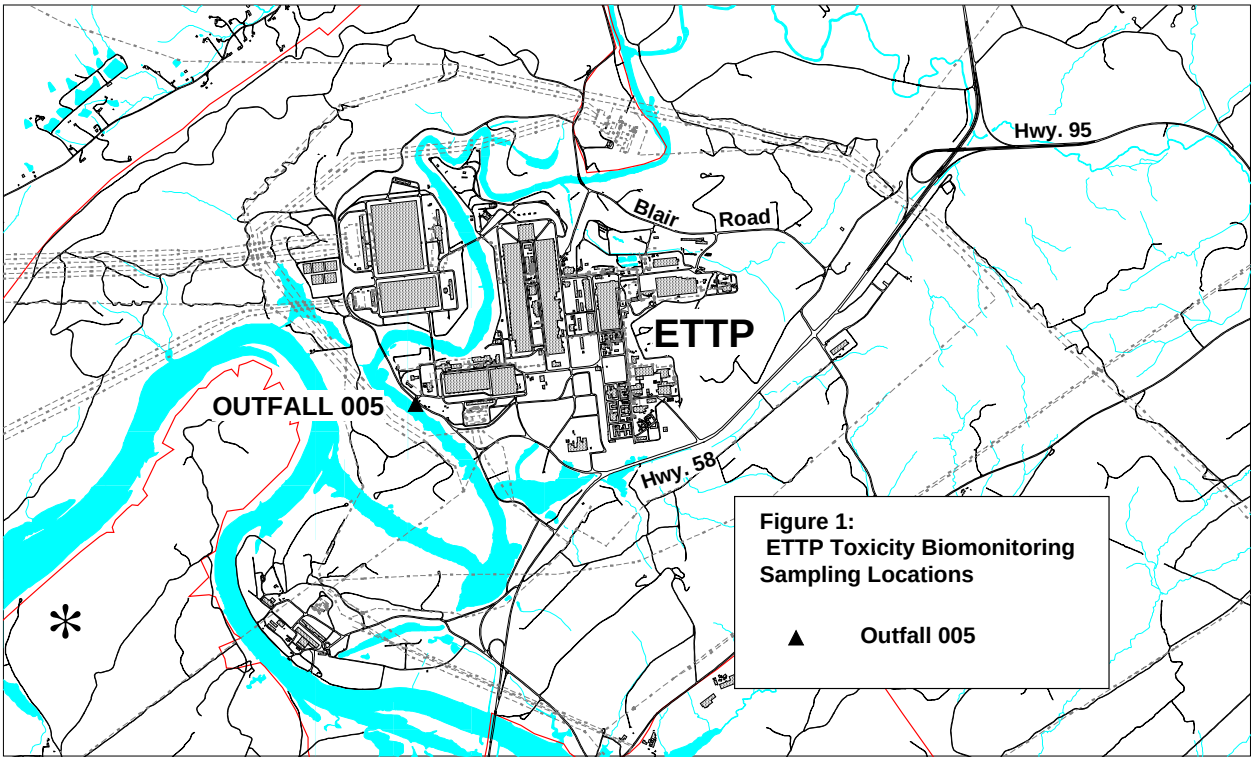
The TDEC/DOE Oversight personnel collected three 24-hr composite samples (4/23, 4/24 and 4/27/01) from ETTP, Outfall 005, K-1203 Sewage Treatment Plant (STP), and one 24-hr composite sample (6/10-11/2001) from ORNL, Outfall X-02, Coal Yard Runoff Treatment Facility (CYRTF). The ORNL X-02 facility did not have sufficient discharge to provide a second effluent sample.

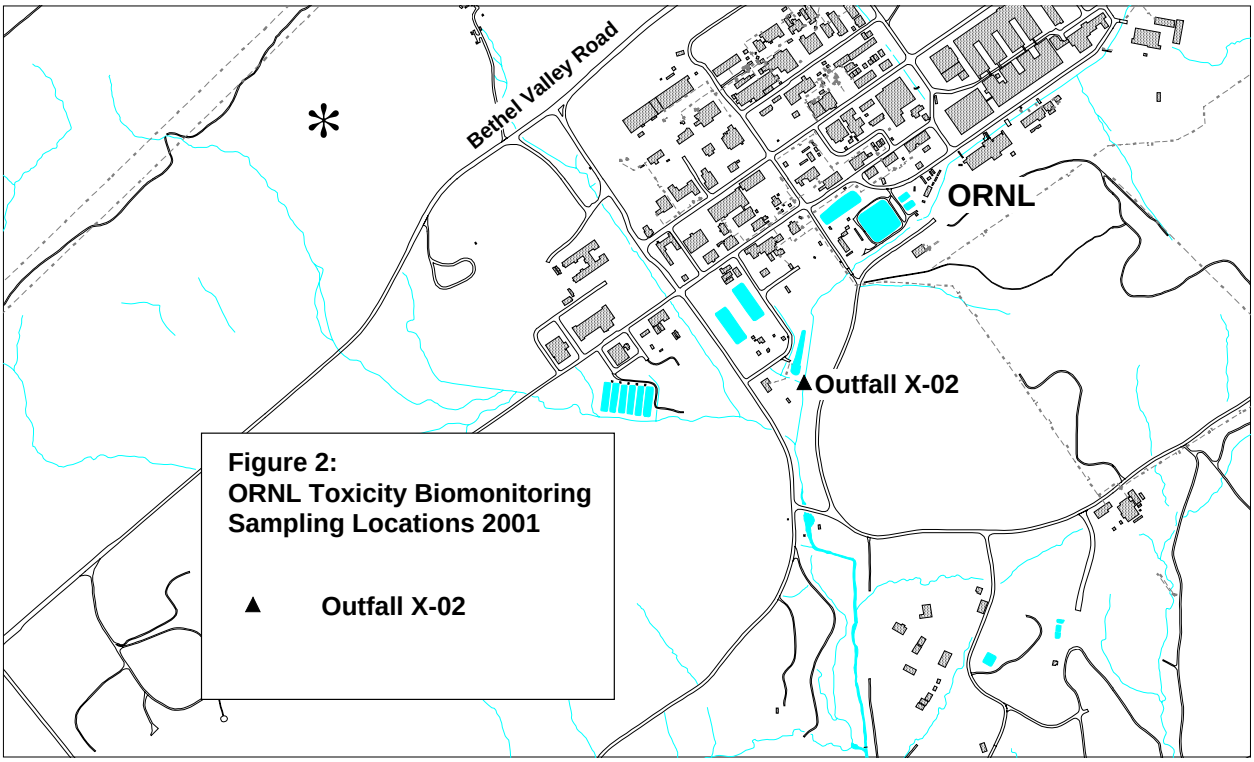
The quantities of effluents to be collected were determined by the State Aquatic Toxicity Laboratory in Nashville based on each site's operating permit. Samples were transported to the Knoxville State Branch Laboratory where they were packaged and prepared for transport via bus to the State Aquatic Toxicity Laboratory in Nashville on the day of each collection.

DOE-O contacted pertinent personnel at DOE prior to sampling to ensure that a health physicist would be available to screen all equipment and samples for contamination prior to removing any materials from the facility.

Toxicity of DOE effluents was evaluated by the State Toxicological Laboratory based on 3-Brood *Ceriodaphnia dubia* Survival and Reproduction Test and a 7-Day *Pimaphales promelas* Larval Survival and Growth Test.

The State Aquatic Toxicity Laboratory procedures for chronic test were followed in accordance with EPA guidelines (EPA/600/4-91/002) and the TN Environmental Laboratories Standard Operating Procedures Manual 2000 and NPDES permits #'s TN0002941 and TN0002950.


Hwy. 95
Blair
Road
ETTP
OUTFALL 005
Hwy. 58
*
Figure 1:
ETTP Toxicity Biomonitoring
Sampling Locations
Outfall 005


Bethel Valley Road
*
ORNL
Outfall X-02
Figure 2:
ORNL Toxicity Biomonitoring
Sampling Locations 2001
Outfall X-02

Results and Discussion

The results of the toxicity tests are expressed as the concentrations of effluent that is lethal to 50% of the test organisms (LC_{50}) during a 96-hour period. Thus, the lower the value, the more toxic an effluent. The tests also detail wastewater's no-observed-effect concentration (NOEC) the highest concentration tested that does not significantly reduce survival or growth of fathead minnows or survival and reproduction of *Ceriodaphnia.*

The DOE NPDES permits specify effluent concentrations for which toxicity is to be demonstrated.

Summary Results from the ETTP STP (Outfall 005), 2001 Toxicity Test

The National Pollutant Discharge Elimination System Permit No. TN0002950 issued by Tennessee Department of Environment and Conservation Division of Water Pollution Control specifies that:

For the ETTP's Sewage Treatment Plant (STP) Outfall 005, toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 hours in 14.6% effluent (LC_{50}) or the no observable effect concentration (NOEC) for survival, reproduction/growth is less than 4.2% for the discharge.

Table 1. Toxicity Test Results of ETTP STP (Outfall 005), Wastewaters, 2001

Test date	Test species	Test	Permit Requirements	Test Results	Pass/ Fail
4/23-27/2001	*Ceriodaphnia dubia*	LC_{50}[1] @ 96 hrs	>14.6%	NAT[3]	Pass
		NOEC[2] Survival	≥4.2%	14.6%	Pass
		NOEC[2] Reproduction	≥4.2%	14.6%	Pass
	Pimephales promales	LC_{50}[1] @ 96 hrs	>14.6%	NAT[3]	Pass
		NOEC[2] Survival	≥4.2%	NCT[4]	Pass
		NOEC[2] Growth	≥4.2%	NCT[4]	Pass

[1] LC_{50} = the concentration as percentage of full-strength wastewater) that kills 50% of the test organisms in 96 hours.
[2] NOEC = no observable effect concentration, the highest effluent concentration at which *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth is not significantly different from the control.
[3] No Acute Toxicity.
[4] No Chronic Toxicity.

DOE has tested effluent from K-1203 twice during 2000 and twice during 2001 with fathead minnows and *Ceriodaphnia dubia*. Below are the review results of the DOE performed toxicity tests as contained in the ORR Annual Site Environmental Report (ASER) for 2000 and Monthly Discharge Monitoring Reports (DMRs) for 2001. At the time of this report the ORR ASER for 2001 was not available.

Table 2. DOE Toxicity Test Results of ETTP STP (Outfall 005), Wastewaters, 2000 and 2001

Test date	Test species	LC_{50}[1] (>14.6% effluent)	NOEC[2] (4.2% effluent)	Pass/ Fail
January 2000	*Ceriodaphnia dubia*	>100%	100%	Pass
	Pimephales promales	>100%	100%	Pass
July 2000	*Ceriodaphnia dubia*	>100%	100%	Pass
	Pimephales promales	>100%	100%	Pass
January 2001	*Ceriodaphnia dubia*	>100%	100%	Pass
	Pimephales promales	>100%	100%	Pass
July 2001	*Ceriodaphnia dubia*	>14.6%	4.2%	Pass
	Pimephales promales	>14.6%	4.2%	Pass

[1] LC_{50} = 96 hours lethal concentration for 50% of test organisms.
[2] NOEC = No observable effect concentration

Summary Results from the ORNL CYRTF (Outfall X-02), 2001 Toxicity Test

The National Pollutant Discharge Elimination System Permit No. TN0002941 issued by Tennessee Department of Environment and Conservation Division of Water Pollution Control specifies that:

For the ORNL's Coal Yard Runoff Treatment Facility (CYRTF), Outfall X-02, toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 hours in 4.2% effluent (LC_{50}) or the no observable effect concentration (NOEC) for survival, reproduction, and growth is less than 1.3% for the discharge. Because of the batch mode of discharge at Outfall X-02, the limit for the NOEC will only apply if discharges for the period of the test allow sampling to renew the solutions. If discharge from X-02 will not be long enough for the 96 hour test to have a renewal sampling, a 48 hour LC_{50} calculation will be used to determine compliance with the limit.

Table 3. Toxicity Test Results of ORNL CYRTF (Outfall X-02), Wastewaters, 2001

Test date	Test species	Test	Permit Requirements	Test Results	Pass/ Fail
6/11/2001	*Ceriodaphnia dubia*	LC_{50}[1] @ 96 hrs	>4.2%	NAT[3] @ 48 hrs[4]	Pass
		NOEC[2] Survival	≥1.3%	[5]	Pass
		NOEC[2] Reproduction	≥1.3%	[5]	Pass
	Pimephales promales	LC_{50}[1] @ 96 hrs	>4.2%	NAT[3] @ 48 hrs[4]	Pass
		NOEC[2] Survival	≥1.3%	[5]	Pass
		NOEC[2] Growth	≥1.3%	[5]	Pass

[1] LC_{50} = the concentration as percentage of full-strength wastewater) that kills 50% of the test organisms in 96 hours.
[2] NOEC = no observable effect concentration, the highest effluent concentration at which *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth is not significantly different from the control.
[3] No Acute Toxicity.

[4] Results from the 48 hours LC_{50} calculation were used to determine compliance with the limit rather than 96 hours LC_{50} due to the insufficient discharge.
[5] Insufficient duration of discharge for determination of NOEC. The 48 hour LC_{50} calculation used to determine compliance with the limit (the limit for NOEC did not apply as per NPDES permit.)

DOE has tested effluent from CYRTF four times during 2000 and 2001 with fathead minnows and *Ceriodaphnia dubia*. Below are the review results of the DOE performed toxicity tests as contained in the ORR Annual Site Environmental Report (ASER) for 2000 and Monthly Discharge Monitoring Reports (DMRs) for 2001. At the time of this report the ORR ASER for 2001 was not available.

Table 4. DOE Toxicity Test Results of ORNL CYRTF (Outfall X-02), Wastewaters, 2000 and 2001

Test date	Test species	LC_{50}[1] (>4.2% effluent)	NOEC[2] (1.3% effluent)	Pass/ Fail
February 2000	*Ceriodaphnia dubia*	>4.2% [3]	[4]	Pass
	Pimephales promales	>4.2% [3]	[4]	Pass
June 2000	*Ceriodaphnia dubia*	>4.2% [3]	[4]	Pass
	Pimephales promales	>4.2% [3]	[4]	Pass
August 2000	*Ceriodaphnia dubia*	>4.2% [3]	[4]	Pass
	Pimephales promales	>4.2% [3]	[4]	Pass
November 2000	*Ceriodaphnia dubia*	>4.2% [3]	[4]	Pass
	Pimephales promales	>4.2% [3]	[4]	Pass
February/March 2001	*Ceriodaphnia dubia*	>4.2% [3]	[4]	Pass
	Pimephales promales	>4.2% [3]	[4]	Pass
June 2001	*Ceriodaphnia dubia*	>4.2% [3]	[4]	Pass
	Pimephales promales	>4.2% [3]	[4]	Pass
August 2001	*Ceriodaphnia dubia*	>4.2% [3]	[4]	Pass
	Pimephales promales	>4.2% [3]	[4]	Pass
November 2001	*Ceriodaphnia dubia*	>4.2% [3]	[4]	Pass
	Pimephales promales	>4.2% [3]	[4]	Pass

[1] LC_{50} = 96 hours lethal concentration for 50% of test organisms.
[2] NOEC = No observable effect concentration
[3] Results from the 48 hours LC_{50} calculation were used to determine compliance with the limit rather than 96 hours LC_{50} due to the insufficient discharge.
[4] Insufficient duration of discharge for determination of NOEC. The 48 hour LC_{50} calculation used to determine compliance with the limit (the limit for NOEC did not apply as per NPDES permit).

Conclusions

The independent toxicity biomonitoring testing of the DOE discharges confirmed that there was no toxicity exhibited by the effluents from the ETTP Sewage Treatment Plant (STP) and ORNL Coal Yard Runoff Treatment Facility (CYRTF) and that both DOE treatment facilities complied with conditions of their NPDES permits.

At the time of this report the DOE Oak Ridge Reservation (ORR) Annual Site Environmental Report (ASER) for 2001 was not available. The results of the 2001 state's testing program were compared to DOE's self-monitoring program results that were published in the DOE ORR ASER for 2000 and the Monthly Discharge Monitoring Reports (DMRs) for 2001.

In all tests, DOE reported no acute or chronic toxicity to the test organisms as demonstrated. DOE also reported no statistically significant difference between tested effluent concentrations and control with regards to both survival and reproduction for *Ceriodaphnia dubia* (water flea) and with regards to survival and growth for *Pimephales promelas* (fathead minnow.)

Test results of toxicity biomonitoring testing on the samples collected by the division and the results reported by DOE indicate that there was no toxicity exhibited in either species tested, and that DOE treatment facilities met toxicity conditions of their NPDES permits for the calendar year of 2001.

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Chapter 1 SURFACE WATER MONITORING

Bear Creek Uranium Study (RMO)

Principle Author: John Edward Sebastian: RRPT, PG, GEO III

Abstract

The western portion of Y-12 in Bear Creek Valley has been the site of numerous disposals of waste from DOE operations. Notably, several million kilograms of depleted uranium has been disposed in the valley. Uranium is delivered into Bear Creek and its associated karst and fracture flow groundwater systems along a few discrete, high concentration, low flow surface and subsurface drainages. This suggests that methodologies could be developed to extensively limit the uranium being transported from waste disposal areas into the creek and its associated groundwater.

In order to determine the fate and transport of uranium in the Bear Creek hydrological system, staff from the Tennessee Department of Environment and Conservation collected water and sediment samples along the stream (between km 4.64 and 11.97), its tributaries, and associated springs/seeps. Each sample was analyzed for its gross alpha concentration (which was determined to be representative of the uranium concentration by isotopic analysis). The results and flow estimates were used to calculate the flux of gross alpha, and by implication uranium traveling through Bear Creek Valley hydrological system. These fluxes can be used to demonstrate the movement and fate of uranium dissolved in the waters of Bear Creek Valley.

The alpha flux data indicates that uranium in Bear Creek parallels the gaining and losing behavior of Bear Creek (with seasonal adjustments) and its associated karst groundwaters – reemerging around km 7 where spring SS-6 joins the flow of Bear Creek. Uranium below km 7 shows the expected process of dilution and a less expected one of a diminished flux. Loss of contaminant mass into the subsurface drainage and/or the chemical precipitation of uranium onto stream sediments are suggested as potential explanatory mechanisms. A rough equivalence in stream sediment concentrations for gross alpha at various points along the creek suggests that chemical precipitation is at least partly responsible: if contaminant mass were being lost to the subsurface, one would expect a decrease in sediment concentration levels.

Introduction

During the 2001 calendar year, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division collected radiological samples and flow measurements along Bear Creek, its tributaries, and associated springs in an attempt to determine the transport and fate of uranium disposed in Bear Creek Valley. As uranium is an emitter of alpha radiation, gross alpha measurements were used as indicators of the uranium concentrations. The flows in the streams were estimated at the time the samples were taken. This enabled a measurement of flux to be generated by combining the reported concentrations of gross alpha with the flow measurements.

Location: Bear Creek Valley is located on the Oak Ridge Reservation (ORR) within East Tennessee's Valley and Ridge Physiographic Province. Bear Creek drains the western portion of

the Department of Energy (DOE) Y-12 Complex. The valley lies between Pine Ridge to the map north and Chestnut ridge to the map south and trends in a general northeasterly and southwesterly manner common to the long narrow valleys of this physiographic province. Bear Creek, along with its intregal complex karst and fracture flow groundwater systems, drains a number of sites used to dispose of depleted uranium from historic DOE processes.

Geology: **Fractured clastic and carbonate Cambrian aged sedimentary rocks of the Conasauga Group underlie Bear Creek Valley. Sedimentary beds strike in a general northeastern manner and dip approximately 30 to 45 degrees toward the southeast. Within the regional structure of imbricate thrust blocks (Bear Creek Valley and its bordering ridges form part of one such block), deformation can become too complex for description. The valley is segregated into a number of fractured clastic formations that underlie the majority of the valley's surface and one well developed karst unit, the Maynardville Limestone, which runs parallel to the base of Chestnut Ridge and in some areas forms the lower slopes of Chestnut Ridge. Adjacent to the Maynardville Limestone are the dolomites of the Cambrian and Ordovician aged Knox Group formations. The Knox Group aquifer is also a developed karst dominated by conduit flow groundwaters.**

Hydrogeology: **Groundwater and surface water movement in the valley is dominated by the well-developed karst of the Maynardville Formation. With the exception of occasional deeper fracture systems within the clastics, much of the meteoric water that falls on the clastic units is carried by surface or near surface runoff into Bear Creek and its underlying karst aquifer. The creek itself is merely the surface expression of the well-developed karst drainage and is composed of a series of gaining and losing stretches. Entire portions of the creek's flow can be observed seasonally (in at least one location) cascading into a swallet formed in the limestone of the creek bed. In this regard, the upper reaches only flow continuously when the underlying karst has been filled to capacity with rainwater. A series of springs, which most likely represent a seasonally variable mixture of waters from the Maynardville karst aquifer and the adjacent Knox Group aquifer exists along the base of Chestnut Ridge and contributes considerable flow to the Bear Creek System.**

Methods and Materials

For the purposes of the study, gross alpha concentrations were utilized to represent dissolved phase uranium (an alpha particle emitter) in the waters of the Bear Creek system. To verify the usefulness of the assumption that gross alpha was an acceptable substitute for more direct measurements of uranium, alpha spectography was performed on a number of samples, in addition to the measurements of gross alpha concentrations. Results show that in this environment gross alpha is a reasonable indicator of uranium concentrations moving through the Bear Creek system.

The gross alpha concentrations and flow measurements were used to calculate the flux of alpha moving through the Bear Creek system. This flux is expressed as pico-curies per second (i.e., pCi/L X L/s $\Rightarrow$ pCi/s). The locations and timing of sampling were chosen in such a manner as to

provide a determination of both the source and fate of the contaminant mass. Generally, sampling points (Figure 1) can be divided into three groups: springs, tributaries, and Bear Creek itself. However, each of the sampling points in the three groups tends to be related to each other in such a way that a cross section of the watershed was sampled essentially simultaneously.

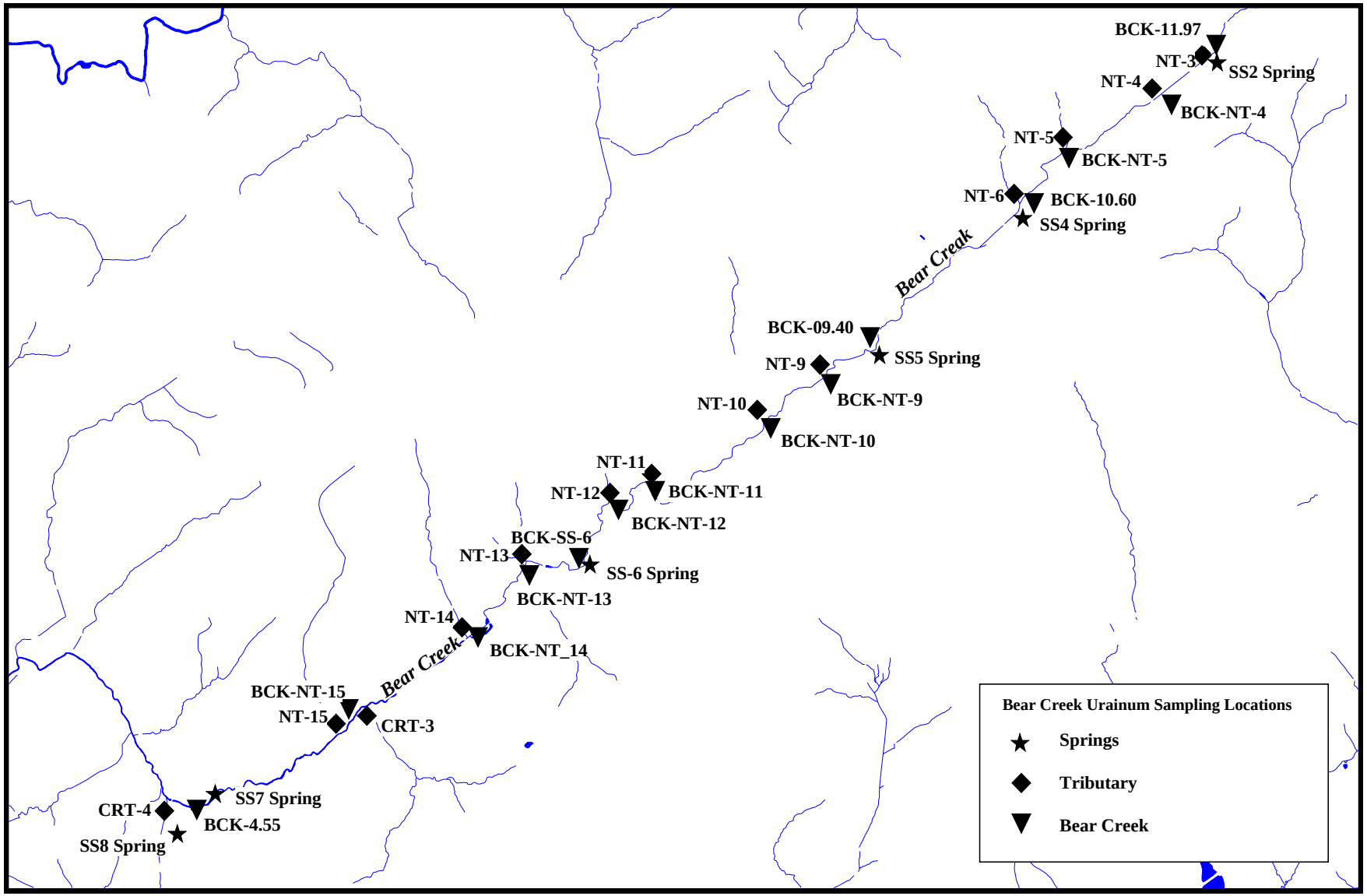

Figure 1: Uranium and Gross Alpha Sampling Points in Bear Creek Valley during 2001

Flow measurements at each location were derived by available means ranging from visual estimates to the use of weirs. Despite the sometimes questionable measuring techniques for flow, it can be seen that even given large margins of error (50% or greater) no changes in conclusions would be warranted. In this regard, flow measurements taken by the U.S. Geologic Survey along Bear Creek indicate that there are no measurements in this study that are unusual or unlikely for Bear Creek or its environs. Further, the data gathered is logical from one sampling point to another and consistent with other studies performed in the same area. Problematic areas of the study include the uncertainty associated with the flow measurements and the lack of an accurate method to gauge the movement of sediments.

Results and Discussion

Bear Creek: Results of samples taken from Bear Creek show not only an expected diminution of gross alpha concentrations, but an unexpected decrease in the flux of gross alpha. Figures 2 through 4 illustrate the decrease in gross alpha fluxes. Seasonal variations in this flux can be attributed to gaining and losing sections of the creek and a general diminution in contaminant loads, due to chemical precipitation and the possible loss of waters into subsurface drainage.

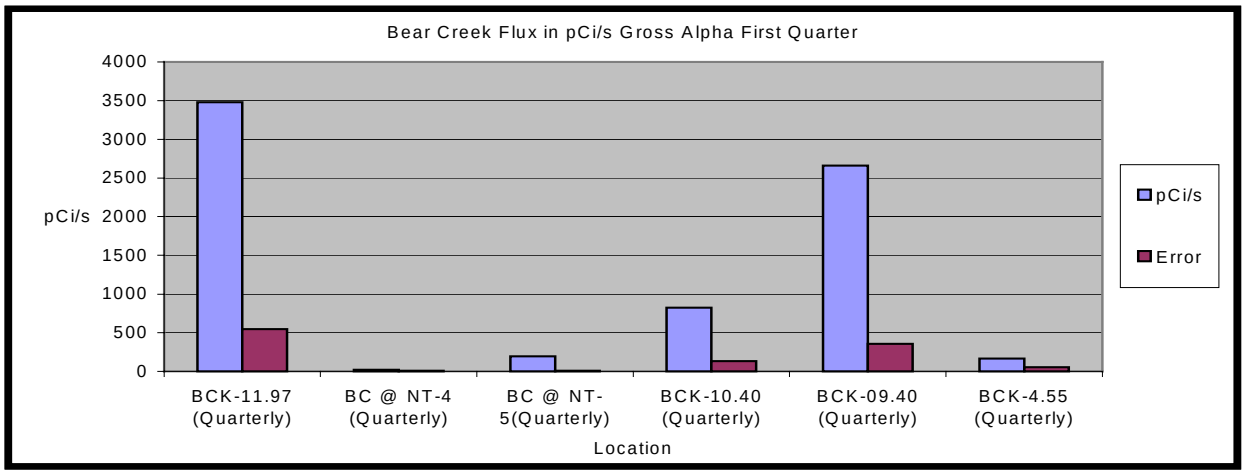

Figure 2: Flux of Gross Alpha in Bear Creek for the First Quarter of 2001

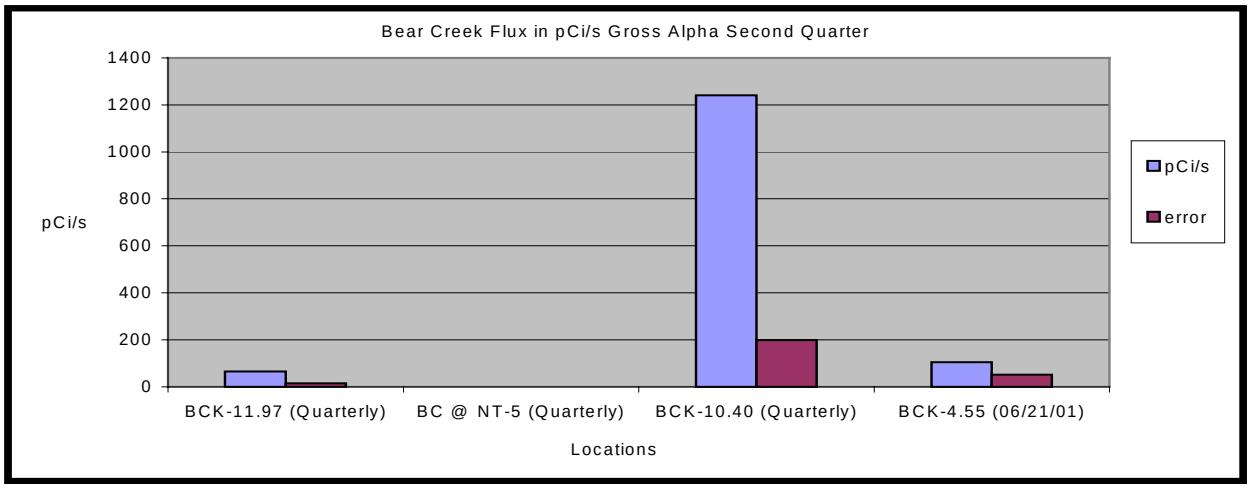

Figure 3: Flux of Gross Alpha in Bear Creek for the Second Quarter of 2001

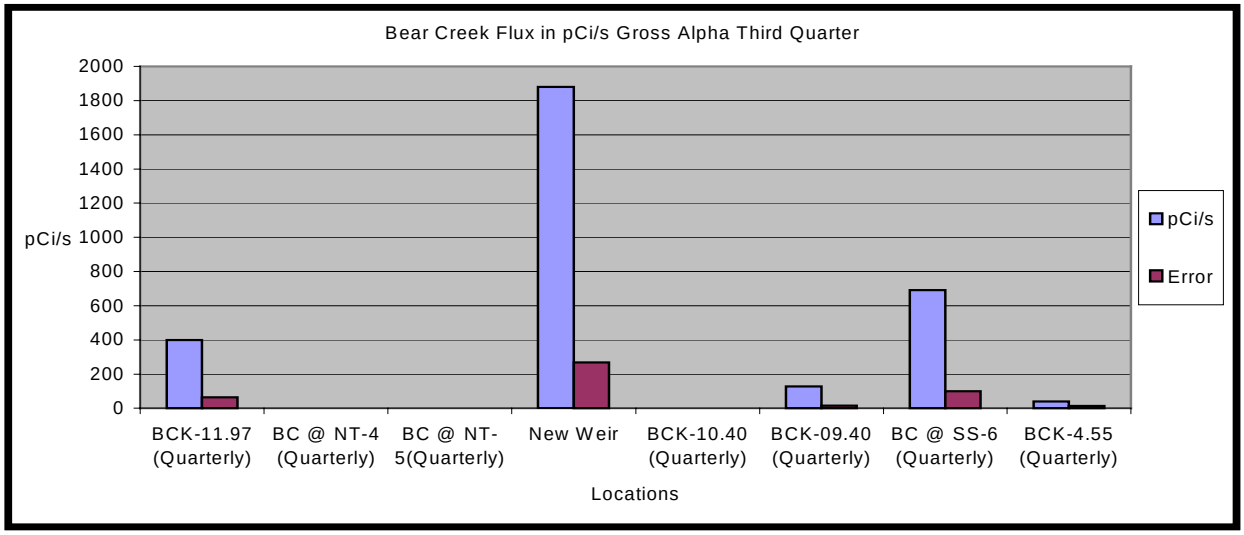

Figure 4: Flux of Gross Alpha in Beer Creek for the Third Quarter of 2001

Springs: As can be seen in Figures 5 through 7, the flux of gross alpha contributed by the springs was considerably less than the portion borne by Bear Creek's Waters. This is interpreted to indicate that uranium contamination in the springs is, in general, sourced from losing reaches of Bear Creek. The balance of these spring waters being sourced from uncontaminated water originating from the Knox Aquifer that underlies Chestnut Ridge. In fact, gross alpha fluxes and concentrations can be essentially traced from losing reaches of Bear Creek around kilometer 11.0 to the springs downgradient, particularly spring SS-4. Also of interest, is the close mimicking of the behavior of contaminant flux from the springs with that of Bear Creek itself, demonstrating the strongly coupled nature of the surface and groundwater systems above and within the conduit dominated flow regimes of the karst aquifer.

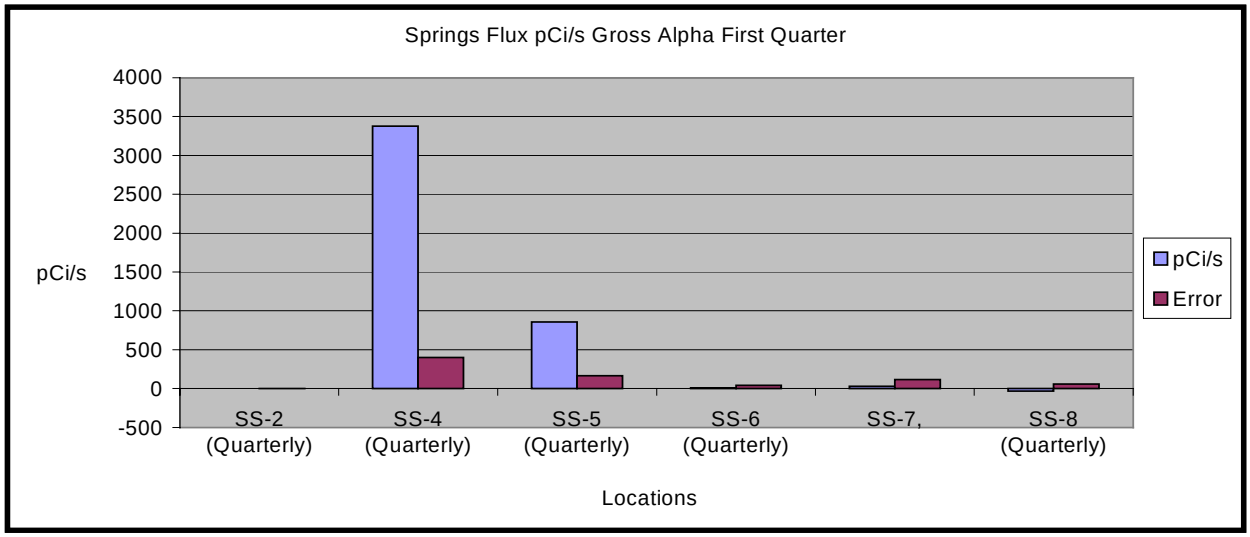

Figure 5: Flux of Gross Alpha in Springs on Beer Creek in the First Quarter of 2001

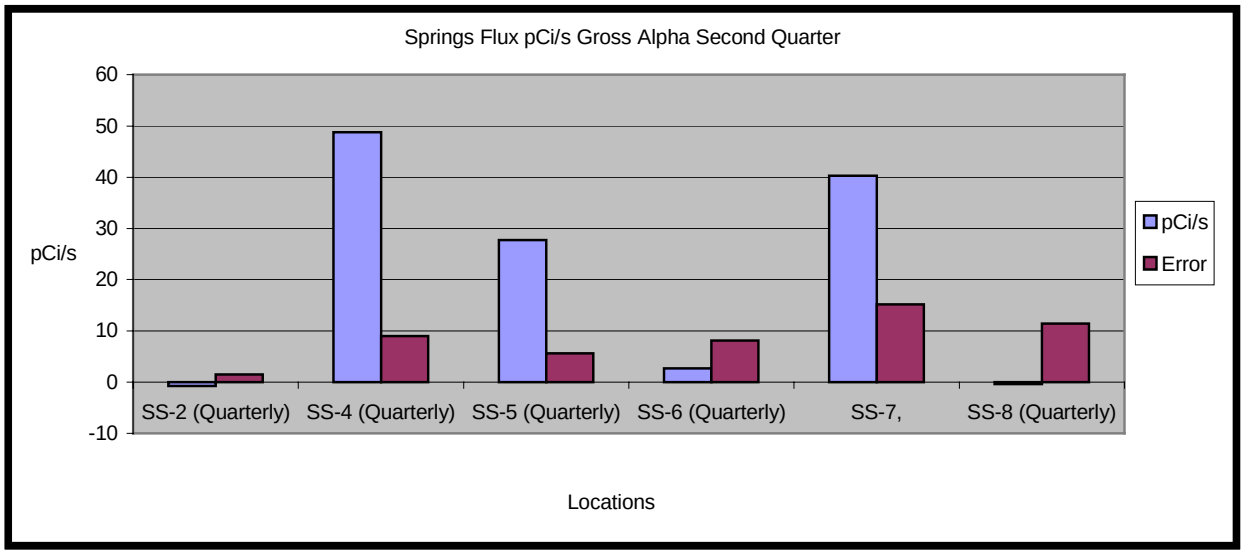

Figure 6: Flux of Gross Alpha in Springs on Bear Creek in the Second Quarter of 2001

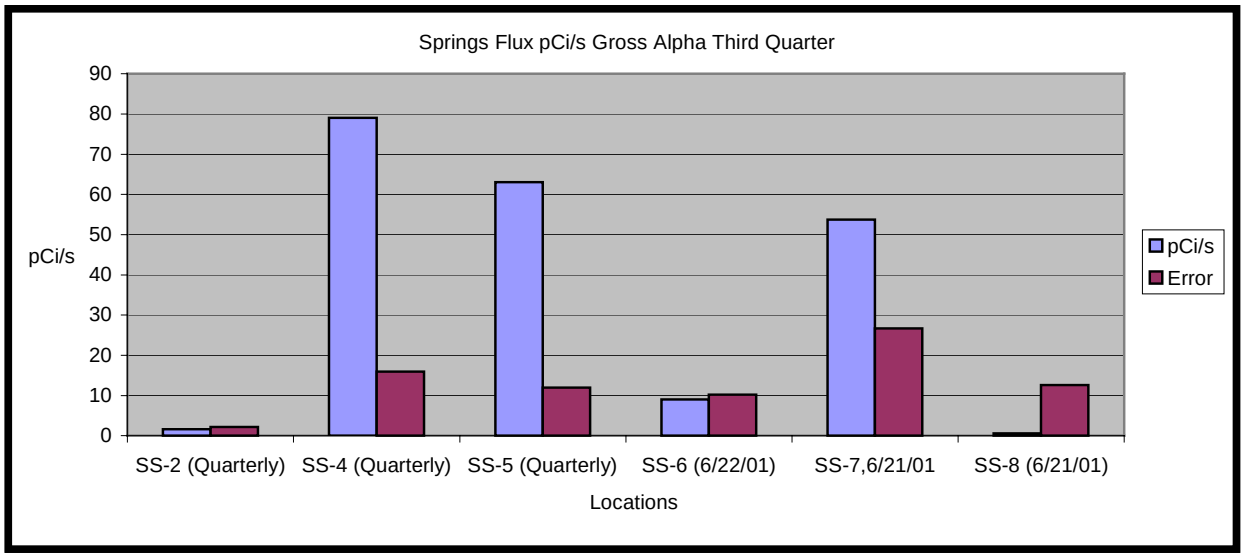

Figure 7: Flux of Gross Alpha in Springs on Beer Creek in the Third Quarter of 2001

Tributaries: As expected, it is apparent from sampling results (Figures 8 through 10) that the tributaries which drain uranium waste disposal areas are the major sources of gross alpha contamination in Bear Creek Valley. More significant is the indication that much of the contaminant flux seems to be limited to a very small number of tributaries that contribute alpha contamination in high flux low - volume waters.

In particular, it can be seen that NT-3 is the most significant contributor to gross alpha contamination in the water of Bear Creek. NT-3 produced a flux of over 5000 pCi/s. The only other significant contributors to Bear Creek alpha concentrations were NT-6 (producing > 200 pCi/s), and the JES Sludge Seep (producing > 80 pCi/s).

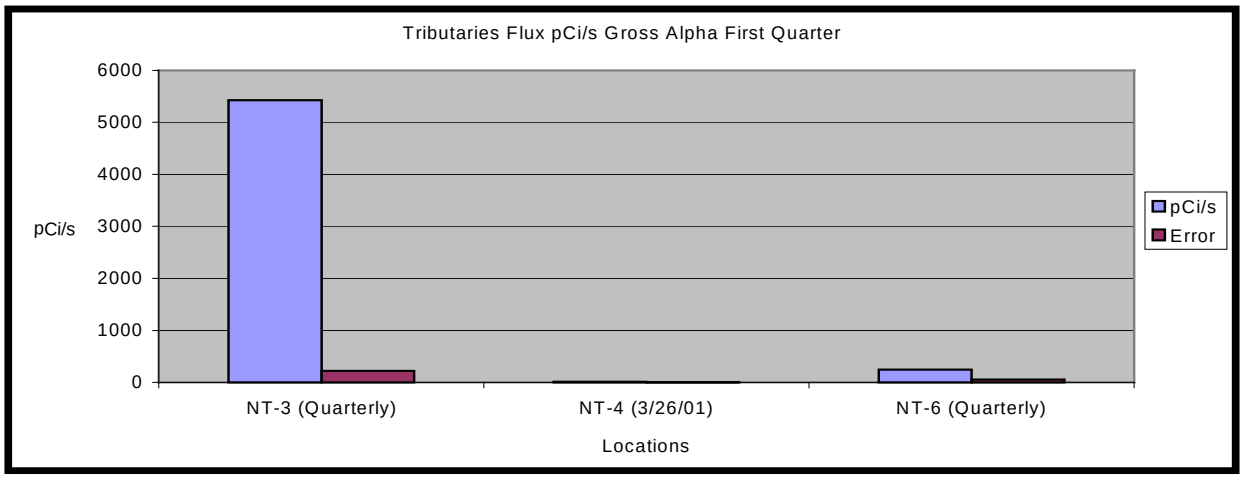

Figure 8: Flux of Gross Alpha in Beer Creek Tributaries in the First Quarter of 2001

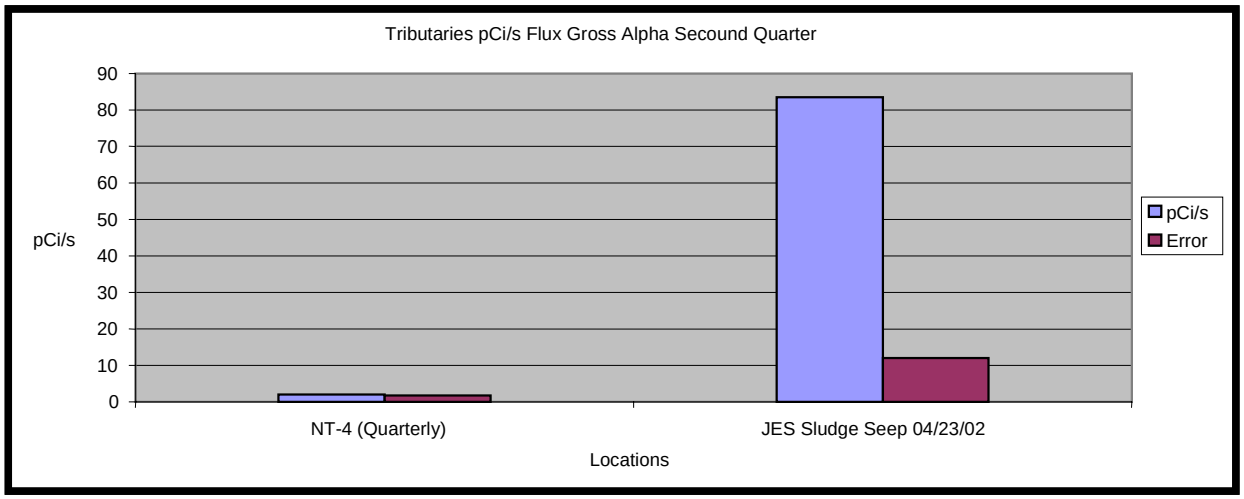

Figure 9: Flux of Gross Alpha in Beer Creek Tributaries in the Second Quarter of 2001

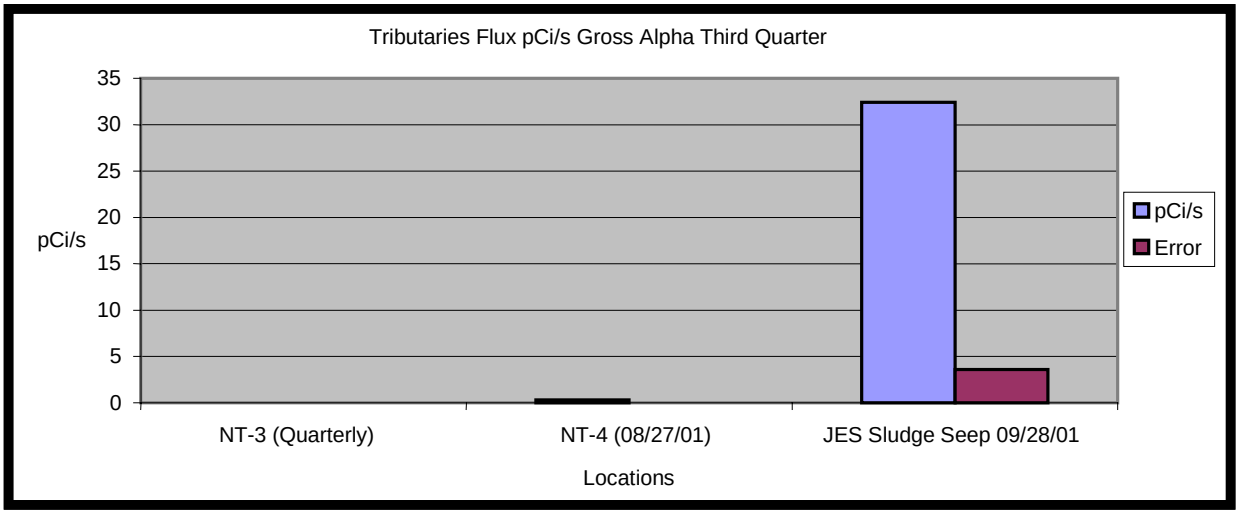

Figure 10: Flux of Gross Alpha in Beer Creek Tributaries in the Third Quarter of 2001

Gross Alpha Flux in the Bear Creek Hydrological System: Study results suggest that much of the gross alpha contamination in the waters of Bear Creek Valley are transported from uranium waste disposal areas along individual discrete pathways in surface drainages (e.g., NT-3 & NT-6) or through shallow subsurface fractures such as those that supply the JES Sludge Seep. The vast majority of the contaminant mass is delivered by surface drainages (particularly NT-3).

The gross alpha contaminant mass then follows the gaining and losing reaches of Bear Creek, being lost to the stream in dolines such as the one located at km 11.0 and various other fractures/conduits that exist on the stream bed. It appears that much of the contaminant "lost" from Bear Creek emerges in the series of springs along the base of the northern slope of Chestnut Ridge (in particular spring SS-6) and presumably in gaining reaches of Bear Creek itself. Some of the contaminant mass is probably lost to the deeper Maynardville Aquifer and has been detected from time to time in deep picket wells in this formation.

Bear Creek from spring SS-6 (km 7) to Hwy 95 (km 4.6) exhibits a considerable decrease in the gross alpha flux. This is presumably due to the continued neutralization of waters bearing dissolved uranium and the continued loss of contaminant bearing waters to the deeper portions of the Maynardville Aquifer.

Conclusions

Gross alpha measurements in Bear Creek and its environs are a reasonable method by which to demonstrate the uranium burden being carried by the Bear Creek System.

Most of the uranium in Bear Creek is delivered along discrete, low volume, high concentration flows during the wetter parts of the year. In this regard, tributary NT-3 is a particular problem. Uranium also enters the creek through discrete fractures. This suggests that uranium inputs to the creek can be identified and controlled.

Once in the creek, uranium transport mimics the karst conduit mixed surface and subsurface drainage of the Maynardville Limestone, reemerging in the springs along Chestnut Ridge (after being diluted with water from the Knox Aquifer) and in springs that are intregal to the bed of Bear Creek itself. This process of reemergence is substantially completed around spring SS-6 with greatly diminished gross alpha fluxes at SS-7 and SS-8, except during the dryer parts of the year when a lower flow regime dominates the karst system. It should also be considered that in the dryer parts of the year inputs from the karst aquifer underlying Chestnut Ridge have diminished and the entire system loses water to evapotransporation.

Between the point where SS-6 drains into Bear Creek (approximately km 7) and Hwy 95 (km 4.6) the flux of uranium was seen to decrease, presumably due to neutralization of the dissolved phase and loss to the deeper aquifer.

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Chapter 2 SEDIMENT

Ambient Sediment Monitoring Program

Principle Author: John Peryam

Abstract

Sediment analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. The DOE Oversight Division conducted sediment sampling at 26 sites in 2001. The sediments were analyzed for inorganic and organic constituents. The levels of the compounds were compared to the Department of Energy's Preliminary Remediation Goals (PRGs) for Use at the Department of Energy Oak Ridge Operations Office. Based on the designation of the water bodies involved, the values were compared to the recreational PRGs. Under recreational land use, individuals are assumed to be exposed to contaminated media while playing, fishing, hunting, or engaging in other outdoor activities. Exposure could result from ingestion of soil or sediment, inhalation of vapors from soil or sediment, dermal contact with soil or sediment, external exposure to ionizing radiation emitted from contaminants in soil or sediment, and consumption of fish.

Based on this comparison, the sediments showed no levels of concern for the contaminants that were analyzed for. Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek increase as one goes downstream. Although the levels of mercury are well below the PRGs, they are higher than all of the other sediment sampling sites. For this reason, the investigation of sediment mercury in this region of the river will be expanded in 2002 to include two sampling sites at Tennessee River Miles 569.0 and 567.0. These sites are located one mile upstream and one mile downstream of the mouth of the Clinch River.

Introduction

Sediment analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. Samples can be collected for a variety of chemical, physical, toxicological, and biological investigations. The DOE Oversight Division conducts an ambient sediment sampling program that includes 30 sampling sites, numbered 2 through 31. Sites 2 through 7 are located on the Clinch River and have been sampled since 1994. In 1997, fifteen sampling sites were added to the ambient sediment monitoring program. These new sites are tributaries of the Clinch River located on the Oak Ridge Reservation. The new sites are numbered 8 through 22 and listed in Figure 1.1. Three new stations were added in 1999. These three new sites are numbered 23 through 25; two of these are background streams (Clear Creek and White Creek) and the other unnamed stream is a tributary of the Clinch River that flows through Oak Ridge. In 2000, two sites on the Clinch River were added downstream of Brashear's Island. These new sites were 26 at Clinch River Mile (CRM) 9.0 and 27 at CRM 7.0. In 2001, two more sites at Clinch River Miles 4.0 and 0.0 were added to the program.

The sampling stations were sampled once during 2001, with the exception of a few dry streams. Samples were analyzed for organic and inorganic parameters. Sediment data was compared with

Department of Energy's Preliminary Remediation Goals (PRGs) for Use at the U.S. Department of Energy Oak Ridge Operations Office, ES/ER/TM-106/R1.

Analytical Parameters

Inorganics: aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc.

Organics (extractables): butylbenzylphthalate, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, di-n-octylphthalate, diethylphthalate, dimethylphthalate, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitroso-di-n-propylamine, isophorone, nitrobenzene, 2,4-dinitrotoluene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, napthalene, phenanthrene, pyrene, bis(2-chloroethyl) ether, bis(2-chloroethoxy)methane, bis(2-chloroisopropyl) ether, 4-bromophenylphenyl ether, 4-chlorophenylphenylether, hexachlorocyclopentadiene, hexachlorobutadiene, hexachlorobenzene, hexachoroethane, 1,2,4-trichlorobenzene, 2-chloronapthalene, 4-chloro-3-methyl phenol, 2-chlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,4,6-trichlorophenol.

Organics (pesticides/PCBs): aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC (lindane), technical chlordane, alpha-chlordane, gamma-chlordane, 4,4-DDD, 4,4-DDE, 4,4-DDT, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, heptachlor, heptachlor epoxide, toxaphene, methoxychlor, PCB 1016/1242, PCB 1221, PCB 1232, PCB 1248, PCB 1254, PCB 1260, PCB 1262.

Sampling Stations

Site 2 - Anderson County Water Treatment Plant: Samples are taken from the Clinch River bottom with a Ponar mini-dredge from a boat in an area approximately 20 to 40 feet from the west bank of the river, just offshore from the water treatment plant. The coordinates are approximately 36º 03' 46" N latitude and 84º 11' 49" W longitude. This site is upstream of any possible DOE impacts and is a reference site in this respect. It may, however, show effects of any agricultural, industrial and residential activities upstream.

Site 3 - Melton Hill Park: Samples are taken by the same methods as used at Site 2 in an area approximately 20 to 40 feet from the west bank of the river approximately one half mile downstream of the Knoxville Utility Board's pumping station. The coordinates are approximately 35º 56' 39" N latitude and 84º 14' 21" W longitude.

Site 4 - Grubb Islands: Samples are taken by the same methods as used at Site 2 in an area approximately 20 to 40 feet from the west bank of the river approximately 100 to 200 feet downstream of the larger Grubb Island. The coordinates are approximately 35º 53' 52" N latitude and 84º 22' 24" W longitude.

Site 5 - Brashear Island: Samples are taken by the same methods as used at Site 2 in an area approximately 20 to 40 feet south of the last sandbar (going downstream) of the river approximately 400 to 500 feet upstream of Brashear Island. The coordinates are approximately 35º 55' 13" N latitude and 84º 26' 02" W longitude.

Site 6 - Bull Run Steam Plant: Samples are taken by the same methods as used at Site 2 in an area approximately 20 to 40 feet of the west bank of the river at a point near the upstream end of the skimmer wall. The coordinates are approximately 36º 01' 28" N latitude and 84º 10' 02" W longitude.

Site 7 - Water Treatment Plant: Samples are taken by the same methods as used at Site 2 in an area approximately one half mile downstream of the Water Treatment Plant Intake. The coordinates are approximately 35º 58' 30" N latitude and 84º 12' 30" W longitude.

Site 8 - Scarboro Creek: Samples are taken by scooping sediment from the creek bottom at a point where the creek begins forming soft sediment deposits (clay, silt, and organic matter) near the confluence with Melton Hill Lake. The coordinates are approximately 35º 58' 59" N latitude and 84º 13' 00" W longitude.

Site 9 - Kerr Hollow Branch: Samples are taken by scooping sediment from the creek bottom at a point where the creek begins forming soft sediment deposits (clay, silt, and organic matter) about 50 feet from the confluence with Melton Hill Lake. The coordinates are approximately 35º 58' 45" N latitude and 84º 13' 37" W longitude.

Site 10 - McCoy Branch: Samples are taken by scooping sediment from the creek bottom at a point where the creek begins forming soft sediment deposits (clay, silt, and organic matter) at the confluence with Melton Hill Lake. The coordinates are approximately 35º 57' 57" N latitude and 84º 14' 54" W longitude.

Site 11 - Western Branch: Samples are taken by scooping sediment from the creek bottom at a point about 150 yards from the confluence with Melton Hill Lake. The coordinates are approximately 35º 58' 00" N latitude and 84º 15' 05" W longitude.

Site 12 - East Fork of Walker Branch: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 150 feet in distance, beginning about 100 feet from the confluence with Melton Hill Lake. The coordinates are approximately 35º 57' 22" N latitude and 84º 15' 58" W longitude.

Site 13 - Bearden Creek: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 150 feet in distance, beginning about 20 feet from the confluence with Melton Hill Lake. The coordinates are approximately 35º 56' 05" N latitude and 84º 17' 01" W longitude.

Site 14 – Unnamed Stream: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 30 feet in distance, beginning about 100 feet from the confluence with

the Clinch River. The coordinates are approximately 35º 54' 25" N latitude and 84º 16' 39" W longitude.

Site 15 – Unnamed Stream: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 30 feet in distance, beginning about 75 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 21" N latitude and 84º 17' 06" W longitude.

Site 16 – Unnamed Stream: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 30 feet in distance, beginning about 100 feet from the confluence with the Clinch River. The coordinates are approximately 35º 53' 22" N latitude and 84º 18' 04" W longitude.

Site 17 – Unnamed Stream: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 750 feet in distance, beginning about 1500 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 14" N latitude and 84º 20' 12" W longitude.

Site 18 - Raccoon Creek: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 50 feet in distance, beginning about 1000 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 12" N latitude and 84º 21' 05" W longitude.

Site 19 - Ish Creek: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 50 feet in distance, beginning about 1000 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 11" N latitude and 84º 21' 33" W longitude.

Site 20 - Grassy Creek: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 50 feet in distance, beginning about one half mile from the confluence with the Clinch River. The coordinates are approximately 35º 54' 36" N latitude and 84º 22' 55" W longitude.

Site 21 – Unnamed Stream: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 20 feet in distance, approximately 100 feet from the confluence with Grassy Creek. The coordinates are approximately 35º 54' 36" N latitude and 84º 22' 57" W longitude.

Site 22 – Unnamed Stream: Samples are taken by scooping sediment from the creek bottom in a length of the stream about 20 feet in distance, beginning at the opening of the culvert that brings water from the K-1515C lagoon, approximately 100 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 29" N latitude and 84º 23' 25" W longitude.

Site 23 – Unnamed Stream: This stream is located behind Warehouse Road in Oak Ridge. Samples are taken a short distance from the Clinch River embayment at Clinch River Mile 51.1.

The approximate coordinates are 36º 02' 19" N latitude and 84º 12' 47" W longitude. This site is upstream of any possible DOE impacts and is a reference site in this respect. It may, however, show effects of any agricultural, industrial and residential activities upstream.

Site 24 – White Creek: This stream is located in the Chuck Swann Wildlife Management Area in Union County. Samples are taken about 1/3 mile downstream from an old TVA water monitoring facility about one mile upstream of Norris Lake. The approximate coordinates are 36º 20' 47" N latitude and 83º 53' 42" W longitude.

Site 25 – Clear Creek: This stream is located near Norris Dam near Clinch River Mile 77. Samples are taken near a water storage facility about one mile upstream of the river. The approximate coordinates are 36º 12' 49" N latitude and 84º 03' 33" W longitude. This is a background site.

Site 26 – Clinch River Mile 9.0: Samples are taken by the same methods as used at Site 2. The coordinates are approximately 35º 54' 36" N latitude and 84º 26' 15" W longitude.

Site 27 – Clinch River Mile 7.0: Samples are taken by the same methods as used at Site 2. The coordinates are approximately 35º 53' 37" N latitude and 84º 27' 46" W longitude.

Site 28 – Clinch River Mile 4.0: Samples are taken by the same methods as used at Site 2. The coordinates are approximately 35º 53' 29" N latitude and 84º 29' 55" W longitude.

Site 29 – Clinch River Mile 0 .0: Samples are taken by the same methods as used at Site 2. The coordinates are approximately 35º 51' 52" N latitude and 84º 32' 01" W longitude.

Methods and Materials

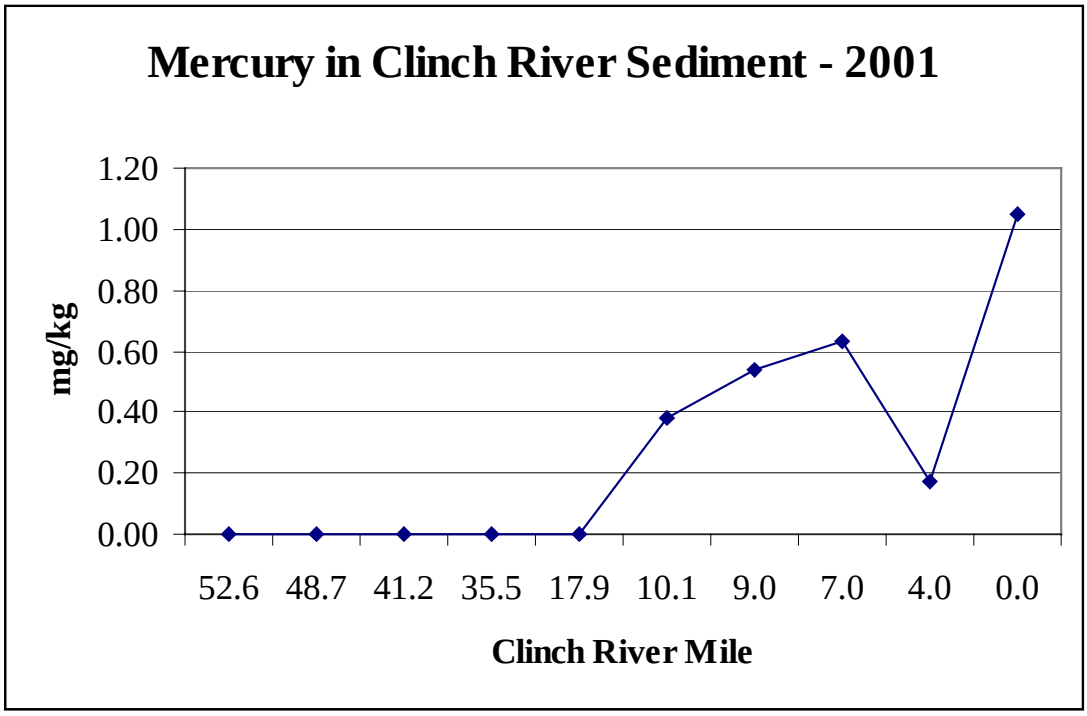
Sediment samples were taken during May using the methods described in the 2001 Ambient Sediment Monitoring Plan. The Tennessee State Laboratories processed the samples, according to EPA approved methods.

Results and Discussion

Inorganic Analyses

Inorganic analyses of sediment samples taken in 2001 showed no levels of concern based on comparisons with DOE's Preliminary Remediation Goals (PRGs) for recreation use of soils and sediments. PRGs are used for comparison because there are no state or federal sediment criteria. Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek (sites 5, 26, and 27: river miles 10.1, 9.0, and 7.0, respectively) increase as one goes downstream. Although the levels of mercury are well below the recreational PRG (1100 mg/kg), they are higher than all of the other sediment sampling sites (see Chart 1.1).

Chart 1.1 Mercury in Clinch River Sediment 2001



Organic Analyses

Organic analyses of sediment samples taken in 2001 showed no levels of concern based on comparisons with DOE's PRGs for recreation uses of soils and sediments.

Conclusions

Sediment data from 2001, samplings show no levels of contamination that exceed DOE Preliminary Remediation Goals (PRGs) for recreation. If in the future, these sediments are to be used for agricultural and/or other purposes, analysis may be performed to determine the suitability for these new purposes. Until that time, recreational PRGs will continue to be applied. Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek increase as one goes downstream. Although the levels of mercury are well below the recreational PRG, they are higher than all of the other sediment sampling sites. For this reason, the investigation of sediment mercury in this region of the river will be expanded in 2002 to include two new sampling sites at Tennessee River Miles 569.0 and 567.0.

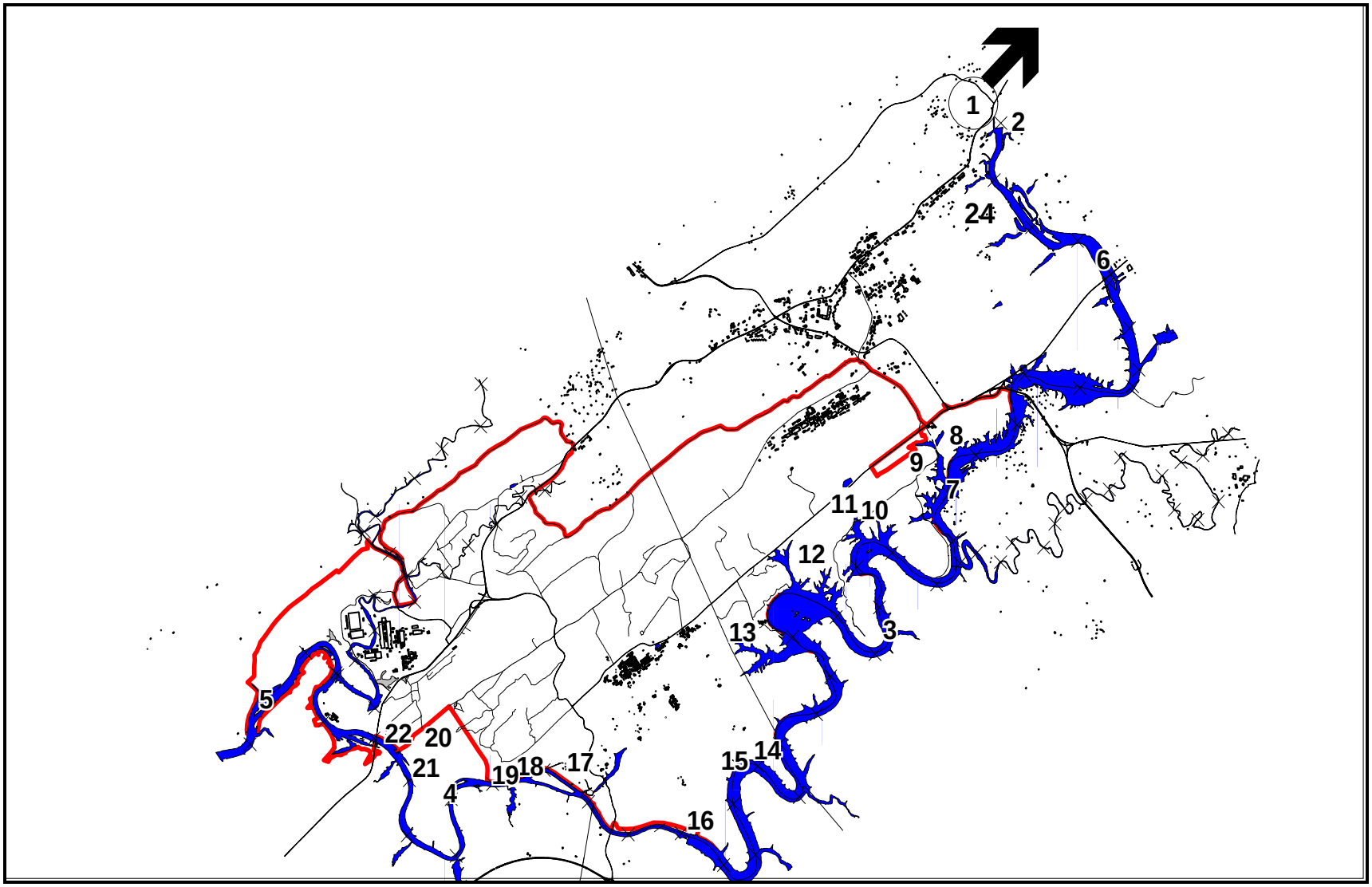
Table 1.1 Sample Locations

Site	Location	Clinch River Mile	Site Abbreviation
1	Downstream of Norris Dam, Clinch River	78.7	CRM 78.7
2	Anderson County Water Treatment Plant	52.6	CRM 52.6
3	Downstream Williams Bend	35.5	CRM 35.5
4	Grubb Islands	17.9	CRM 17.9
5	Brashear's Island	10.1	CRM 10.1
6	Bull Run Steam Plant	48.7	CRM 48.7
7	Water Treatment Plant	41.2	CRM 41.2
8	Scarboro Creek	41.2*	SCM 0.1
9	Kerr Hollow Branch	41.2*	KHM 0.01
10	McCoy Branch	37.5*	MCM 0.1
11	Western Branch	37.5*	WBM 0.1
12	East Fork Walker Branch	33.2*	EFWM 0.1
13	Bearden Creek	31.8*	BCM 0.01
14	Unnamed Stream	27.0	HCM 0.01
15	Unnamed Stream	26.6	CCM 0.01
16	Unnamed Stream	23.0	PCM 0.1
17	Unnamed Stream	20.0*	JCM 0.1
18	Raccoon Creek	19.5*	RCM 0.1
19	Ish Creek	19.1*	ICM 0.1
20	Grassy Creek	14.55*	GCM 0.1
21	Unnamed Stream	14.55*	CHM 0.1
22	Unnamed Stream	14.45*	WAM 0.01
23	New Stream north of Pilot Knob and south of Warehouse Road.	51.1*	ECM 0.1
24	White Creek	n.a.	WCM 0.1
25	Clear Creek	77.7	CLM 0.1
26	Clinch River Mile 9.0	9.0	CRM 9.0
27	Clinch River Mile 7.0	7.0	CRM 7.0
28	Clinch River Mile 4.0	4.0	CRM 4.0
29	Tennessee River at confluence of Clinch River	0.0	CRM 0.0
30	Tennessee River Mile 569	n.a.	TRM 569
31	Tennessee River Mile 567	n.a.	TRM 567

*This figure is the approximate Clinch River Mile where the tributary meets the river.
**Stream was dry.

Note: Site 1, shown on Figure 1.1, is a water sampling only location

Figure 1.1. Ambient Sediment Monitoring Sites (See Table 1.1)



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Chapter 3 BIOLOGICAL/FISH AND WILDLIFE

Canada Geese Monitoring

Principal Author: Roger Petrie

Abstract
On June 26 and June 27, 2001, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) conducted oversight of the annual Canada Geese (*Branta canadensis*) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study is to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese showed elevated gamma counts.

Introduction
A large population of Canada geese, both resident and transient, frequents the Oak Ridge Reservation (ORR) (Crabtree 1998). The thriving goose population in this area makes this animal an easily accessible food for area residents. Geese with elevated levels of Cs137 in muscle tissue have been found on the ORR (MMES 1987 and Loar 1994). Studies in the 1980s demonstrated that geese associated with the contaminated ponds/lakes on the ORR can accumulate radioactive contaminants quickly and that contaminated geese frequent off site locations (Loar 1990, Waters 1990, MMES 1987)

Every year the Department of Energy (DOE) and Tennessee Wildlife Resource Agency (TWRA) capture geese on the ORR during the annual "Goose Roundup" and perform whole body counts on them to determine if the birds are radioactively contaminated. During the 1998, goose roundup, 38 geese at Oak Ridge National Laboratory (ORNL) contained Cesium 137 concentration that exceeded the game release limit of 5 pCi/g (ORNL 1998). A subsequent study in September 1998 found elevated levels of Cs137 in grass and sediment at two reaches of White Oak Creek south of 3513 Pond and in grass around the 3524 pond (ORNL 1998). Results of the sampling conducted annually since have shown that no geese captured on the reservation had elevated levels of Cs137.

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy (DOE-O) has a sampling plan that is implemented when geese with elevated gamma readings are detected during the regular goose roundup. If any geese with elevated gamma readings are detected then arrangements are made to sample geese that are found in the vicinity of the ORR on private property. This is to determine if contaminated geese are leaving the reservation and are presenting a risk to area hunters.

Results and Discussion
During the 2001 sampling, a total of 232 birds were captured. All of these geese were banded and released. All birds were given total body counts for five minutes with a sodium iodide detector at the TWRA game checking facility on Bethel Valley Road. None of the birds analyzed had levels of gamma above the 5pCi/g game release level.

Conclusion

Since none of the birds analyzed showed signs of contamination, no additional offsite sampling was conducted. Although this does not preclude the possibility of contaminated geese being present off the ORR, it does indicate that there is a reduced likelihood of this situation existing.

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Chapter 3 BIOLOGICAL/FISH AND WILDLIFE

Rapid Bioassessment III: Benthic Macroinvertebrate Biomonitoring in Streams on the Oak Ridge Reservation

Principal Author: Randall P. Hoffmeister

Abstract

Semi-quantitative benthic macroinvertebrate samples were collected from twelve study sites on five streams impacted by past or current Department of Energy (DOE) operations, and six reference sites located on or near the Oak Ridge Reservation (ORR). Using the state of Tennessee Standard Operating Procedures for macroinvertebrate surveys, samples were collected, processed, and analyzed using suggested metrics. A score was calculated from the metrics and a stream site health rating was assigned. Results indicated that all study streams show signs of increasing water quality with distance downstream of DOE influences. However, the number of EPT taxa and the total number of taxa at the study sites continue to be depressed compared to their respective reference locations.

Introduction

Benthic macroinvertebrates are organisms visible to the unaided eye which inhabit the bottom substrates of aquatic systems and include insects, crustaceans, annelids, and mollusks (Platts et al., 1983). Because of their relatively long life spans and sedentary nature, benthic macroinvertebrate community structure can be useful in assessing the condition of an aquatic system. Benthic macroinvertebrate samples were collected from locations on five streams originating on the ORR that have been impacted by past and present DOE operations. Two of these streams, East Fork Poplar Creek and Bear Creek, have been impacted by the Y-12 Plant. One stream, Mitchell Branch, has been impacted by the East Tennessee Technology Park (ETTP) and two streams, White Oak Creek and Melton Branch, have been impacted by operations at the Oak Ridge National Laboratory (ORNL).

The objectives of this study were threefold, (1) to conduct an independent assessment of the condition of streams on the ORR, (2) to confirm bioassessment results conducted by the UT-Battelle and other DOE contractors, and (3) to identify potential impacts from future DOE activities on the aquatic environment.

Method and Materials

Semi-quantitative sampling of benthic macroinvertebrate communities was conducted during the period of May 17, 2001 to June 6, 2001 using the RBP III method described in the *Tennessee Biological Standard Operating Procedures* (SOPs) *Manual: Volume I: Freshwater Aquatic Macroinvertebrates* (1996). Depending on stream size, either a one square meter kick net (larger streams) or a D-frame stationary net (smaller streams) was used to collect benthic macroinvertebrates. In larger streams, two separate riffle kicks were performed by a two person crew. One individual held the double handle kick net perpendicular to the current with the net's weighted bottom resting firmly on the streambed, thereby preventing stream flow underneath the net. Another person disrupted the substrate with a kicking and sweeping motion in a one square

meter stretch just upstream of the net. Benthic organisms were dislodged and drifted into the waiting net. After allowing suitable time for all the debris to flow into the net, the person performing the kick lifted the bottom of the net at each end in a smooth, continuous motion while the person holding the net at the top was careful not to let the top edge dip below the water's surface, thereby allowing organisms to escape. After a second riffle was sampled in an identical fashion, the collected organisms were picked from the net and transferred into a container as a composite sample.

In smaller streams, where riffles were less than one meter wide, four separate riffle kicks were performed using the one-man, D-frame net. A crew member held the single handle net perpendicular to the current with the net's bottom pressed firmly to the streambed. The same person disrupted the upstream substrate for an 18 inch distance and the width of the net, dislodging any benthic organisms. After allowing suitable time for all debris to drift into the net, the net was lifted from the water and three additional riffles were sampled in the same fashion. The debris from all four kicks was composited.

Benthic macroinvertebrate samples were preserved in 80% ethanol with internal and external site specific labels. Labeling information included site name, sampling date, and sampler's initials. If more than one sample container was needed at a site, the debris was split evenly with internal and external labels completed for each container.

Collection methods were modified for sampling in the White Oak Creek watershed due to the presence of radioactive contamination in the stream sediments. Briefly, the two, 1-meter kick samples were combined in a 5-gallon bucket, creek water was added and the sample swirled to suspend the lighter material (including invertebrates) with the elutriate then being poured through a sieve. This process was repeated 5 times, to ensure the thorough collection of organisms. Any material not needed was returned to the creek. Samples from radioactively contaminated sites were processed in laboratory space designated by ORNL Health Physics personnel.

Following the state SOP for laboratory sample processing, a subsample was randomly chosen and the first 200 benthic organisms were removed. If the minimum number of organisms were not collected after the first subsample, a second subsample was randomly chosen and examined. This process was repeated until the target number was achieved. Using a dissecting scope and appropriate references (e.g., Merritt and Cummins 1996, Stewart and Stark 1993, Pennak 1989) organisms were identified to the genus level, with the exception of Chironomids (midges) and Oligochaetes (aquatic worms), and enumerated. Suggested metrics in the state SOP were used for data analyses. The metrics included Comparative Taxa Richness, Indicator Assemblage Index, Dominants in Common, EPT Index, and the Index of Biotic Integrity using the North Carolina Biotic Index. A metric value was calculated at each test site using the appropriate reference site(s) for comparison. Once values were obtained for each of the five metrics, a score of 0 to 6 was given to each metric and the five scores were summed and divided by the maximum possible score (30). The resulting percentage score was then used to rate the biological condition of each study site. A complete verbal description of each metric, the scoring criteria, and associated biological conditions and attributes can be obtained by referencing the state SOP.

Results and Discussion

East Fork Poplar Creek

Oak Ridge National Laboratory (ORNL) Biological Monitoring and Abatement Program (BMAP) reports document the presence of heavy metals including mercury, cadmium, chromium, copper, nickel, and zinc in Upper East Fork Poplar Creek (Hinzman, R.L., 1998).

The scores from each of the five metrics analyzed and the overall rating for each test site are presented in Appendix A. EFK 24.4, EFK 23.4, and EFK 13.8 each rated moderately to severely impaired when compared to the two reference sites at Hinds Creek and Brushy Fork Creek. The farthest downstream site, EFK 6.3, was rated slightly to moderately impaired compared to reference conditions. Figure 1 shows that over the past three years, the numbers of the most pollution intolerant taxa (Ephemeroptera, Plecoptera, and Trichoptera, or EPT) remained at levels lower than those found at the reference sites. The total number of taxa found at the East Fork Poplar Creek sites were also lower than those at the reference sites (Figure 2). Both EPT and the total taxa richness showed a gradual increase in numbers with distance from the Y-12 Plant yet they remained considerably lower than reference conditions. This trend of increasing numbers with distance is most evident in the Spring, 2001 sampling event.

Slight differences existed in the numbers of EPT and total taxa at the East Fork Poplar Creek sites between TDEC-DOE-O and ORNL-Biological Monitoring and Abatement Program (BMAP) results (Appendix B). DOE-O results showed higher numbers of EPT taxa compared to the BMAP results, while the BMAP results had greater numbers of total taxa. Variations in sampling techniques and data analysis may contribute to these observed differences. It is important to note that although the numerical results were dissimilar, the trend of increasing numbers of EPT richness and total taxa richness with distance from the Y-12 Plant was quite evident in both DOE-O and BMAP results.

The stream site ratings in East Fork Poplar Creek have remained consistent over the past three years indicating that the benthic community structure and function continue to be impacted due to the loss of pollution intolerant benthic organisms (EPT) and the total number of taxa.

Bear Creek

Historically, surface water samples collected in Upper Bear Creek have shown high levels of nutrients and radiological activity (gross alpha and gross beta). The S-3 site, located at the west end of the Y-12 Plant, has been identified as the primary source of these impacts (AJA Technical Services, Inc., 1999). Groundwater flow carries nitric acid and uranium-based waste products from the former treatment, storage, and disposal unit toward the creek.

Due to dry stream conditions at BCK 10.3 the day of sampling, a site farther upstream, BCK 11.6, was used as the test site below BCK 12.3. The physical stream characteristics at the sampled location are similar to those found at BCK 10.3 permitting an unbiased comparison with BCK 10.3 and the reference sites. Some variability in benthic macroinvertebrate community and structure is naturally expected, but for our purposes, any differences between BCK 10.3 and BCK

11.6 are assumed to be negligible. Because of the narrow width of Upper Bear Creek, the state method for sampling small streams was used.

Both Bear Creek sites were rated as moderately to severely impaired compared to the reference sites at Gum Hollow Branch and Mill Branch (Appendix A). The severely impaired aspect of the rating was from comparison to conditions at Gum Hollow Branch. Figure 1 and Figure 2 show that for each of the past three years, a trend of increasing numbers in EPT richness and the total taxa richness existed with distance downstream of the Y-12 Plant. The observed numbers, however, were well below those found at the two reference sites indicating that although stream conditions appeared to improve somewhat downstream, Bear Creek remains impacted.

A comparison of the Spring, 2001 sampling results between DOE-O and DOE could not be addressed for Bear Creek due to the lack of DOE published results at the time of report preparation. This information should be included in the 2001 Remediation Effectiveness Report (RER) Draft produced for DOE in late March 2002 (per Holly Clancy, ETTP, personal communication). The data should also be available on OREIS after that time.

White Oak Creek and Melton Branch

The presence of high nutrient levels has been documented in the upper reaches of White Oak Creek inside ORNL boundaries (Ashwood, 1994). Chlorine toxicity has also been problematic in this section. High radiological levels in the form of gross alpha and gross beta persist in Lower White Oak Creek. Cesium and other radionuclides are prevalent as well.

The overall site ratings in the White Oak Creek watershed improved with distance downstream and through the ORNL Plant. The ratings improved a degree from moderately impaired to slightly impaired with distance between WCK 6.8 (the upstream reference site) and WCK 2.3 (Appendix A). All sites rated moderately impaired in 1999 and 2000, furthering the speculation that some stream health improvement had occurred.

Like the previous two years, the number of EPT taxa and the total taxa richness showed a general trend of increasing numbers with distance downstream (Figure 1 and Figure 2). Severely depressed numbers were observed at WCK 6.8 compared to previous years. In 2001, the EPT richness decreased to 7 from previous highs of 15 and 14 (1999 and 2000, respectively) while the total numbers of taxa decreased to 13 from 26 in 1999 and 27 in 2000. Because of these declines in EPT and total taxa richness, a quick inspection of Figure 1 and Figure 2 might lead one to conclude that water quality and conditions at the four test sites have sharply improved to mirror those conditions at the reference site. On the contrary, the data suggests that water quality conditions have deteriorated in the upper reaches of White Oak Creek in the past year, thereby, causing the biota at WCK 6.8 to become impacted with numbers similar to the downstream test sites.

A comparison of DOE-O and ORNL BMAP sampling results within the White Oak Creek watershed for Spring 2001 was not possible at the time of report preparation. The process involving annual contract renewal obligations and requirements by ORNL BMAP to conduct

benthic macroinvertebrate sampling in White Oak Creek have not been finalized. This has caused a delay in BMAP sample processing. The data results are expected to be released later in 2002.

Mitchell Branch

A remediation project was conducted involving the installation of geosynthetic impermeable membranes in a portion of the creek contaminated with petroleum hydrocarbons (Bechtel Jacobs Company, LLC, 1998). Several storm water drains exist in the stretch of the creek between MIK 0.71 and MIK 0.45. Discharges from these storm drains are major contributors affecting water quality and observed impacts on the aquatic environment.

The ETTP sampling location at MIK 0.71 is located within the remediated portion of Mitchell Branch, necessitating a modified small stream sampling technique. A stiff bristled brush was used to loosen organisms clinging to the interlocking concrete tiles that line the streambed. The debris was allowed to drift into the receiving D-frame net. Four riffles were sampled and composited following the procedure used for smaller streams. The scraping technique was a more effective method of dislodging benthic organisms from the surface of the tiles and, especially, from between the tiles than would have been the standard kicking and sweeping method.

Both test sites on Mitchell Branch were rated moderately impaired when compared to upstream reference conditions at MIK 1.43 (Appendix A). Although the ratings have remained unchanged the past three years, both sites continued to show signs of improvement with the number of EPT taxa and the total number of taxa increasing with distance from the remediated portion of the creek (Figure 1 and Figure 2). Despite the apparent improving conditions in water quality, the diversity and function of benthic macroinvertebrate communities in the sampled reaches of Mitchell Branch remained depressed compared to those conditions at the reference site.

The numbers of EPT taxa and total taxa richness were similar between DOE-O and DOE for the Mitchell Branch sites (Appendix B). Any difference in numbers, especially those found at MIK 0.71, might be attributed to the disparity in sampling techniques within the remediated portion. A pulsed disturbance in the benthic community may have occurred as DOE-O sampled a couple days after a rain event. This may have also played a role in the observed differences. Pulsed disruptions with high flow conditions and scouring effects are especially common in small streams like Mitchell Branch.

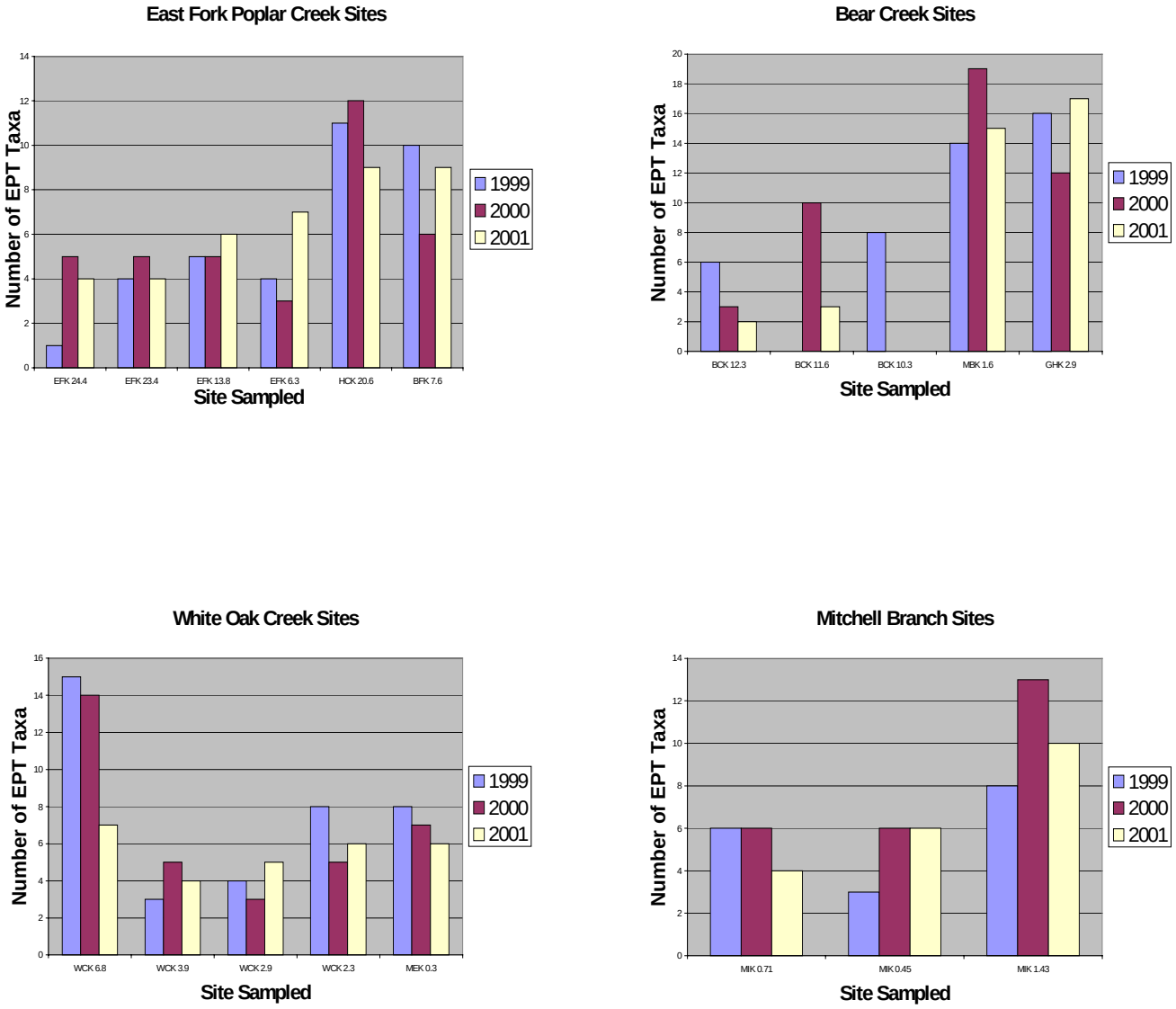

Figure 1. Comparison of the numbers of pollution intolerant benthic macroinvertebrate EPT taxa found in select Oak Ridge Reservation stream sites from Spring, 1999 to Spring, 2001.

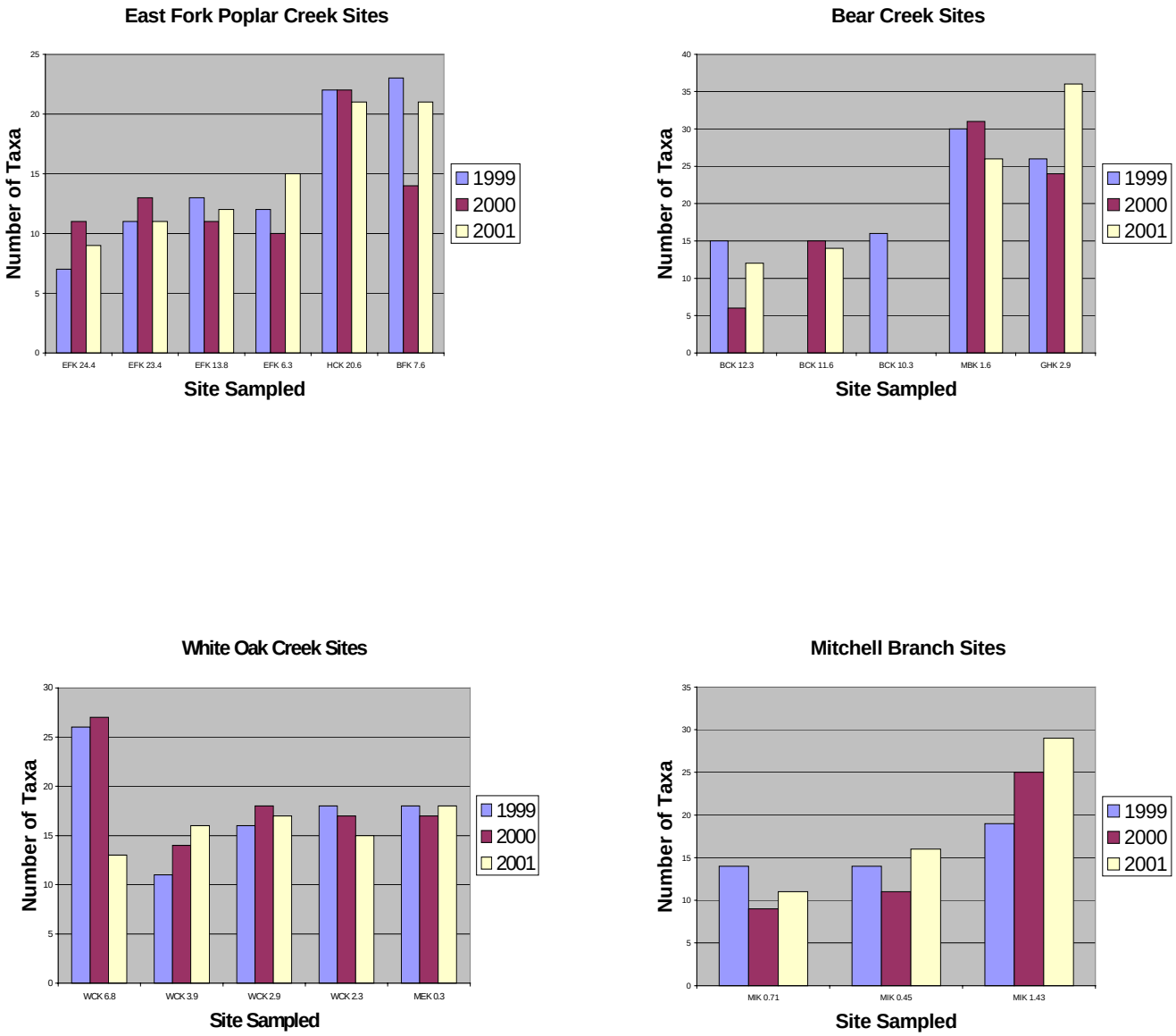

Figure 2. Comparison of the total numbers of benthic macroinvertebrate taxa found in select Oak Ridge Reservation stream sites from Spring 1999 to Spring, 2001.

Conclusions

Of the twelve study sites sampled during Spring 2001 only two, WCK 2.3 and MEK 0.3, rated as high as slightly impaired compared to their reference site, WCK 6.8. The remaining ten study sites rated between moderately impaired to severely impaired with respect to their reference locations. Upper East Fork Poplar Creek including EFK 24.4, EFK 23.4, and EFK 13.8 along with the two Bear Creek sites, BCK 12.3 and BCK 11.6, showed signs of severe impact.

The benthic community in East Fork Poplar Creek seemed to have improved as pollution sensitive EPT taxa and the total number of taxa generally increased with distance from the Y-12 Plant. However, environmental degradation appeared to be persistent relative to the two reference sites. Mercury detected in surface water samples of East Fork Poplar Creek continued to be the largest single contributor to environmental degradation. Noticeable increases in the mean mercury levels were observed at the two most downstream sites compared to previous years.

The benthic condition in Bear Creek continued to show signs of slight improvement with distance from the Y-12 Plant. However, elevated NO_3 and NO_2 nitrogen concentrations and various metal constituents continued to effect the benthic macroinvertebrate community, particularly, the mayflies (Ephemeroptera). The former S-3 ponds at Y-12 have been identified as the major contributors to groundwater contamination. Extreme low flow conditions during the dry season result in groundwater seepage into the water table. The effect of this influx is observed in marked increases in dissolved nutrients and metals concentrations in surface water samples. Gross alpha and gross beta activity also increased sharply at the two Bear Creek test sites compared to previous years. It is important to note that the natural habitat available for macroinvertebrates at BCK 12.3 continues to be less than optimal, and may have an impact on this site's score. Continued sampling in Bear Creek may capture any effects associated with the construction and operation of the Environmental Management Waste Management Facility near BCK 11.6.

Surface water samples indicated that elevated levels of the gamma radionuclide Cesium-137 along with high gross alpha and gross beta radioactivity remained persistent in White Oak Creek. Deteriorating water quality at the reference site, WCK 6.8, was evident in the depressed numbers of EPT taxa and total number of taxa compared to previous years. Construction activities associated with the SNS facility during 2001 seemed to have a significant effect on the benthic community. DOE-O will sample WCK 6.8 in 2002 as a reference site but, depending on the results, it may be necessary to consider it a future study site with a new reference location found.

Conditions at the sampled locations of Mitchell Branch continue to be less than optimal. Three ETTP storm water outfalls, SD-170, SD-180, and SD-190, circumvent MIK 0.71 and MIK 0.45. SD-170 is located just upstream of MIK 0.71 while SD-180 and SD-190 are situated just upstream of MIK 0.45. All three storm drains continue to be the primary sources impacting the aquatic environment. The ETTP Environmental Monitoring Program Midyear Environmental Data Report (Bechtel Jacobs Company LLC, 2001) indicates that toxicity related issues due to the presence of metals, particularly nickel and zinc, and the affluence of volatile organic compounds continue to be problematic. It has been determined through toxicity testing that aquatic organisms including benthic macroinvertebrates are particularly sensitive to nickel and

zinc at relatively low concentrations. Continued monitoring should capture any future influences from these storm drain discharges and test the effectiveness of the petroleum hydrocarbon remediation activities that have occurred in this section of the creek.

As is the case with any long-term environmental monitoring program, it is difficult to make safe and accurate assessments on overall conditions based on the first few sampling events. Future benthic macroinvertebrate biomonitoring and quarterly surface water sampling events in East Fork Polar Creek, Bear Creek, the White Oak Creek watershed, and Mitchell Branch will continue to build on the existing database of information. Continuous field sampling events will aid in more closely defining the sources of any impacts from past, current, and future DOE related activities. The DOE-O biological monitoring efforts will also continue to serve as an independent method of evaluating DOE sampling results.

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Appendix A.

Scores for Each of Five Metrics Analyzed

(1) Comparative Taxa Richness (CTR)

$$CTR = \frac{\text{Species richness at study site}}{\text{Species richness at reference site}} \times 100$$

East Fork Poplar Creek

Site Sampled	Scored with HCK 20.6	Scored with BFK 7.6
EFK 24.4	2	2
EFK 23.4	2	2
EFK 13.8	2	2
EFK 6.3	4	4

Bear Creek

Site Sampled	Scored with MBK 1.6	Scored with GHK 2.9
BCK 12.3	2	0
BCK 11.6	2	0

White Oak Creek and Melton Branch

Site Sampled	Scored with WCK 6.8
WCK 3.9	6
WCK 2.9	6
WCK 2.3	6
MEK 0.3	6

Mitchell Branch

Site Sampled	Scored with MIK 1.43
MIK 0.71	0
MIK 0.45	2

(2) Indicator Assemblage Index (IAI)

$IAI = CA_r/CA_s$

where: CA_r = Total relative abundance of chironomids and annelids at reference site
CA_s = Total relative abundance of chironomids and annelids at study site

East Fork Poplar Creek

Site Sampled	Scored with HCK 20.6	Scored with BFK 7.6
EFK 24.4	0	0
EFK 23.4	0	0
EFK 13.8	0	0
EFK 6.3	6	0

Bear Creek

Site Sampled	Scored with MBK 1.6	Scored with GHK 2.9
BCK 12.3	0	0
BCK 11.6	0	4

White Oak Creek and Melton Branch

Site Sampled	Scored with WCK 6.8
WCK 3.9	0
WCK 2.9	0
WCK 2.3	0
MEK 0.3	0

Mitchell Branch

Site Sampled	Scored with MIK 1.4
MIK 0.71	2
MIK 0.45	0

(3) Dominants in Common (DIC)

where: DIC = five most abundant taxa common to study and reference site

East Fork Poplar Creek

Site Sampled	Scored with HCK 20.6	Scored with BFK 7.6
EFK 24.4	2	2
EFK 23.4	2	2
EFK 13.8	2	2
EFK 6.3	2	2

Bear Creek

Site Sampled	Scored with MBK 1.6	Scored with GHK 2.9
BCK 12.3	2	0
BCK 11.6	2	0

White Oak Creek and Melton Branch

Site Sampled	Scored with WCK 6.8
WCK 3.9	2
WCK 2.9	2
WCK 2.3	4
MEK 0.3	2

Mitchell Branch

Site Sampled	Scored with MIK 1.4
MIK 0.71	2
MIK 0.45	2

(4) EPT Index

EPT Index = Number of distinct EPT taxa at study site X 100
Number of distinct EPT taxa at reference site

East Fork Poplar Creek

Site Sampled	Scored with HCK 20.6	Scored with BFK 7.6
EFK 24.4	0	0
EFK 23.4	0	0
EFK 13.8	0	0
EFK 6.3	2	2

Bear Creek

Site Sampled	Scored with MBK 1.6	Scored with GHK 2.9
BCK 12.3	0	0
BCK 11.6	0	0

White Oak Creek and Melton Branch

Site Sampled	Scored with WCK 6.8
WCK 3.9	0
WCK 2.9	2
WCK 2.3	4
MEK 0.3	4

Mitchell Branch

Site Sampled	Scored with MIK 1.4
MIK 0.71	0
MIK 0.45	0

(5) Index of Biotic Integrity (IBI)

$$NCBI = \Sigma \frac{x_i t_i}{n}$$

$$IBI = \frac{\text{NCBI of reference site}}{\text{NCBI of study site}} \times 100$$

Where: NCBI = North Carolina Biotic Index
and: x_i = number of individuals within a taxa
t_i = tolerance value of a taxa
n = total number of organisms in the sample

East Fork Poplar Creek

Site Sampled	Scored with HCK 20.6	Scored with BFK 7.6
EFK 24.4	6	2
EFK 23.4	6	2
EFK 13.8	6	2
EFK 6.3	6	4

Bear Creek

Site Sampled	Scored with MBK 1.6	Scored with GHK 2.9
BCK 12.3	6	4
BCK 11.6	4	2

White Oak Creek and Melton Branch

Site Sampled	Scored with WCK 6.8
WCK 3.9	6
WCK 2.9	6
WCK 2.3	6
MEK 0.3	6

Mitchell Branch

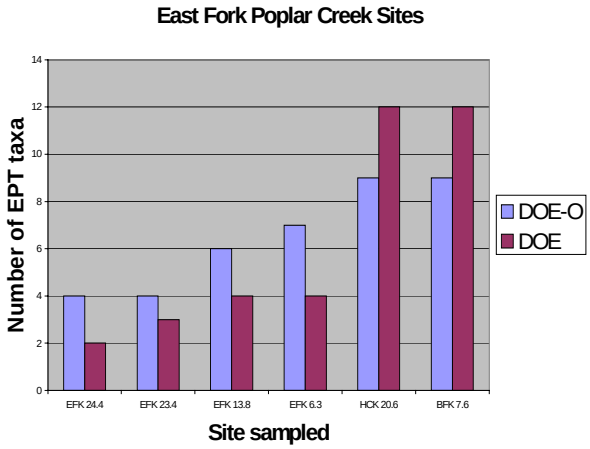
Site Sampled	Scored with MIK 1.4
MIK 0.71	6
MIK 0.45	6

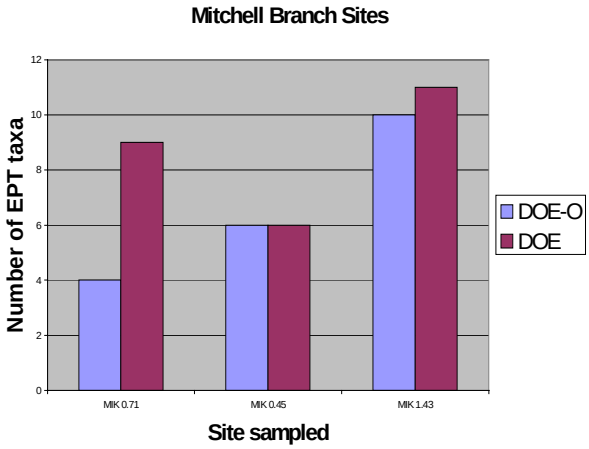
Combined scores for each study site

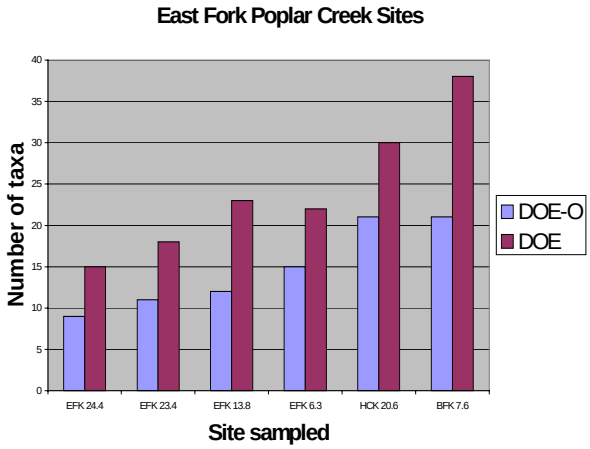
SITE	SCORE (out of a possible of 30)	RATING
EFK 24.4	10 vs. Hinds, 6 vs. Brushy Fork	Moderately to severely impaired
EFK 23.4	10 vs. Hinds, 6 vs. Brushy Fork	Moderately to severely impaired
EFK 13.8	10 vs. Hinds, 6 vs. Brushy Fork	Moderately to severely impaired
EFK 6.3	20 vs. Hinds, 12 vs. Brushy Fork	Slightly to moderately impaired
BCK 12.3	10 vs. Mill Br., 4 vs. Gum Hollow	Moderately to severely impaired
BCK 11.6	8 vs. Mill Br., 6 vs. Gum Hollow	Moderately to severely impaired
WCK 3.9	14 vs. WCK 6.8	Moderately impaired
WCK 2.9	16 vs. WCK 6.8	Slightly to moderately impaired
WCK 2.3	20 vs. WCK 6.8	Slightly impaired
MEK 0.3	18 vs. WCK 6.8	Slightly impaired
MIK 0.71	10 vs. MIK 1.43	Moderately impaired
MIK 0.45	10 vs. MIK 1.43	Moderately impaired

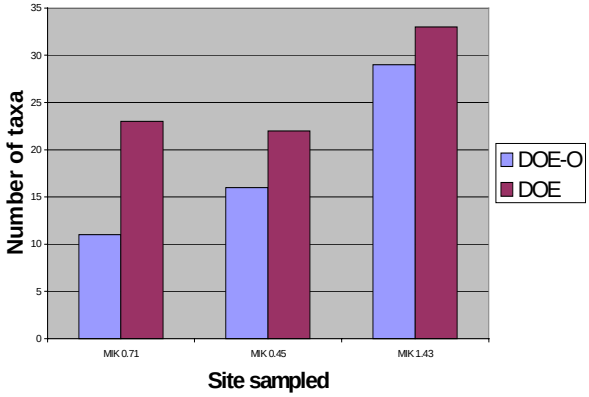
Appendix B

Comparison Between DOE-O and DOE Benthic Macroinvertebrate Sampling Results, Spring 2001.









Chapter 4 DRINKING WATE R

Review of Area Water Systems

Principal Author: Kathleen Kitzmiller

Abstract
To assess possible impacts to public water systems in the area by the Department of Energy (DOE), the Tennessee Department Of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) monitors the quality of water in local streams, the Clinch River and at area water treatment plants. These measures of quality include analytical results reported in Consumer Confidence Reports prepared by area water systems, independent sampling results for raw and treated water, review of emergency operations plans, and review of regulatory inspection reports.

Introduction
Pollution from past and current activities on the Oak Ridge Reservation (ORR) has the potential to impact public water supplies in the area. The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) program sections monitor the quality of water in local streams, in the Clinch River, and at area water treatment plants. In addition, state regulations require public water suppliers to test for an array of contaminants on a regular basis. Should conditions warrant, TDEC might elect to conduct independent sampling of raw water entering area water treatment systems; however, the analytical results obtained by the various monitoring efforts did not indicate a need to do so. Appendix 1 lists public water systems within a fifty-mile radius of the ORR that use surface water, purchased surface water, or groundwater under the direct influence of surface water.

During the past year, in addition to review of water quality measures, oversight of area water systems focused upon the following items:

- Breaks in city of Oak Ridge Raw Water Mains
- city of Oak Ridge Waterborne Disease Emergency Plan
- Clark Center Recreation Park

Discussion
Breaks in city of Oak Ridge Raw Water Mains. Two twenty-four inch raw water mains carry water from the Clinch River to the Oak Ridge Water Treatment Plant located on top of Pine Ridge between the Y-12 plant and the city. The water treatment plant supplies finished drinking water to the city, as well as to the Oak Ridge National Laboratory (ORNL) and Y-12.

In February, the west raw water main ruptured beneath Bear Creek Road near the Y-12 plant entrance. In August, the east raw water main did likewise. In each instance, Y-12 promptly notified the city of the line break. In turn, city workers quickly responded. Pending completion of repairs, the water supply was shut off to Y-12's east sixteen-inch main and to the twenty-four inch main leading to ORNL. Both facilities had maintained water reserves sufficient to permit

normal operations and to provide fire protection. In both cases, water main repairs were completed by the following day.

city of Oak Ridge Waterborne Disease Emergency Plan. In 1994 the city of Oak Ridge developed an emergency plan detailing how it would respond to an outbreak of waterborne disease such as Giardia, Cryptosporidium, or other parasites. The plan resulted from a joint effort by the city of Oak Ridge and its water treatment plant, the Department of Energy (DOE), the state of Tennessee, the Anderson County Health Department, and the Methodist Medical Center. In October, the group met with representatives of area water utility districts to discuss the current version of the waterborne disease emergency plan. The meeting also provided a forum for those present to discuss security measures that have been implemented subsequent to September 11.

Clark Center Recreation Park. Clark Center Recreation Park is located on the McCoy Branch embayment of the Clinch River at RM 37.5 between Gallaher Bend and Freels Bend. Formerly known as Carbide Park, Clark Center Park is roughly 80 acres in size. The park is open to the public for day use only. Although located on DOE land, it is considered a city of Oak Ridge Park. The park lies within the 30,000 acre Three Bends Scenic and Wildlife Management Area.

Historically, water treatment operations at Clark Center fell under the jurisdiction of the Y-12 facility. In May 2000, the Y-12 water treatment plant was transferred to the city of Oak Ridge. However, the Clark Center water treatment systems were not included in the transfer. DOE contractors operated two separate water treatment systems on a seasonal basis, one for the office center and the other for the swimming area bathhouse.

In April 2001, plans were finalized to deliver city water directly to the park. Installation of the PVC pipeline began in June and was finished later during the summer. With the completion of this project, the day-to-day operation of the Clark Center Park distribution system no longer falls under the purview of TDEC DOE-O.

Conclusion

The water quality on the ORR and in the area is well within regulatory limits and will continue to be monitored by this office and the Knoxville Environmental Assistance Center.

Appendix 1 Surface Water, Purchased Surface Water Systems and Groundwater Under Direct Influence of Surface water Systems within 50 Mile Radius of ORR

*** Located directly downstream of ORR**

Water System Name	County	Type
Anderson County Utility Board	Anderson	Surface Water
Clark Center Bath House (closed 07/01/01)	Anderson	Surface Water
Clark Center Office System (closed 07/01/01)	Anderson	Surface Water
Clinton Utility Board	Anderson	Surface Water
Lake City Water Department	Anderson	Purchased Surface Water
Norris Water Commission	Anderson	Groundwater UDI Surface water
North Anderson County Utility District	Anderson	Surface Water
Oak Ridge Department of Public Works	Anderson	Surface Water

Y-12 Plant Water System	Anderson	Purchased Surface Water
Tennessee Cumberland Plateau Campground	Bledsoe	Groundwater UDI Surface water
Alcoa Water System	Blount	Surface Water
Bays Mountain Mobile Home Park	Blount	Groundwater UDI Surface water
Friendsville Water Works	Blount	Purchased Surface Water
Maryville Department of Public Works	Blount	Surface Water
South Blount Utility District	Blount	Purchased Surface Water
Tuckaleechee Utility District	Blount	Purchased Surface Water
Caryville-Jacksboro Utility District	Campbell	Surface Water
Jellico Water Department	Campbell	Surface Water
La Follette Water Department	Campbell	Surface Water
Claiborne County Utility District	Claiborne	Surface Water
Catoosa Utility District	Cumberland	Purchased Surface Water
Crab Orchard Utility District	Cumberland	Surface Water
Crossville Water Department	Cumberland	Surface Water
Dorchester # 15	Cumberland	Groundwater UDI Surface water
Renegade Mountain Water System	Cumberland	Purchased Surface Water
South Cumberland Utility District	Cumberland	Purchased Surface Water
West Cumberland Utility District	Cumberland	Purchased Surface Water
Allardt Water Works	Fentress	Purchased Surface Water
Fentress County Utility District	Fentress	Purchased Surface Water
Jamestown Water Department	Fentress	Surface Water
Rutledge Water System	Grainger	Purchased Surface Water
Washburn School	Grainger	Groundwater UDI Surface water
Bush Brothers # 3	Jefferson	Surface Water
Dandridge Water Department	Jefferson	Purchased Surface Water
Jefferson City Water & Sewer	Jefferson	Surface Water
New Market Utility District	Jefferson	Purchased Surface Water
Shady Grove Utility District	Jefferson	Purchased Surface Water
First Utility District of Knox County	Knox	Surface Water
Grove at Dean Hill Apartments	Knox	Purchased Surface Water
Hallsdale-Powell Utility District	Knox	Surface Water
Knox-Chapman Utility District	Knox	Surface Water
Knoxville Utilities Board # 1 Whitaker Plant	Knox	Surface Water
Knoxville Utility Board # 3 Forks of the River	Knox	Surface Water
Northeast Knox Utility District	Knox	Surface Water
Reserve of Westland Apartments	Knox	Purchased Surface Water
West Knox Utility District	Knox	Surface Water
Christ Our Savior Lutheran Church	Loudon	Purchased Surface Water
Lenoir City Utility Board	Loudon	Surface Water
Loudon Utilities Board	Loudon	Surface Water
Martel Utility District	Loudon	Purchased Surface Water
Tellico Village POA	Loudon	Purchased Surface Water
Advent Home Water System	McMinn	Groundwater UDI Surface water
Athens Utility Board	McMinn	Purchased Surface Water
Bowater Newsprint	McMinn	Surface Water
Calhoun-Charleston Utility District	McMinn	Purchased Surface Water
Camp Cherokee-McMinn County	McMinn	Groundwater UDI Surface water
Conasauga Baptist Church	McMinn	Groundwater UDI Surface water

Englewood Water Department	McMinn	Surface Water
Etowah Utilities	McMinn	Surface Water
Mount Pisgah Baptist Church	McMinn	Groundwater UDI Surface water
New Hopewell Baptist Church	McMinn	Groundwater UDI Surface water
New Zion Baptist Church	McMinn	Groundwater UDI Surface water
Niota Water System	McMinn	Purchased Surface Water
Oak Grove Baptist Church	McMinn	Groundwater UDI Surface water
Pond Hill Baptist Church	McMinn	Groundwater UDI Surface water
Riceville Utility District	McMinn	Purchased Surface Water
Rockview Baptist Church	McMinn	Groundwater UDI Surface water
Sanford Baptist Church	McMinn	Groundwater UDI Surface water
Armstrong Ferry PUA	Meigs	Groundwater UDI Surface water
Decatur Water Department	Meigs	Groundwater UDI Surface water
Good Hope Baptist Church	Meigs	Groundwater UDI Surface water
Walnut Grove Baptist Church	Meigs	Groundwater UDI Surface water
Hiwassee College	Monroe	Groundwater UDI Surface water
Indian Boundary Recreation Area USFS	Monroe	Groundwater UDI Surface water
Madisonville Water Department	Monroe	Purchased Surface Water
Sweetwater Utility Board	Monroe	Surface Water
Tellico Area Services System	Monroe	Surface Water
Brushy Mountain Prison	Morgan	Surface Water
Plateau Utility District	Morgan	Surface Water
Sunbright Utility District	Morgan	Purchased Surface Water
Wolfe Branch Utility District	Morgan	Purchased Surface Water
Monterey Water Department	Putnam	Surface Water
Blue Water Campground & Boat Dock	Rhea	Groundwater UDI Surface water
1Dayton Water Department*	Rhea	Surface Water
Fort Bluff Youth Camp	Rhea	Groundwater UDI Surface water
Grandview Utility District	Rhea	Purchased Surface Water
North Utility District of Rhea County	Rhea	Purchased Surface Water
2Spring City Water System*	Rhea	Surface Water
3Watts Bar Utility District*	Rhea	Surface Water
Cumberland Utility District	Roane	Surface Water
4East Tennessee Technology Park*	Roane	Surface Water
Harriman Utility Board	Roane	Surface Water
5Kingston Water System*	Roane	Surface Water
Oak Ridge National Lab X-10	Roane	Purchased Surface Water
Oliver Springs Water Board	Roane	Purchased Surface Water
Roane Central Utility District	Roane	Purchased Surface Water
Rockwood Water System	Roane	Surface Water
Swan Pond Utility District	Roane	Purchased Surface Water
Watts Bar Utility District	Roane	Purchased Surface Water
Huntsville Utility District	Scott	Surface Water
Oneida Water & Sewer Comm.	Scott	Surface Water
Chalet Village North	Sevier	Purchased Surface Water
Condo Villas of Gatlinburg	Sevier	Purchased Surface Water
Gatlinburg Water Department	Sevier	Surface Water
Knoxville East KOA	Sevier	Groundwater UDI Surface water
Pigeon Forge	Sevier	Surface Water

Sevierville Water System	Sevier	Surface Water
Webb Creek Utility District	Sevier	Purchased Surface Water
Global Stone Tennessee Luttrell	Union	Groundwater UDI Surface water
Hickory Star Marina	Union	Groundwater UDI Surface water
Luttrell-Blaine-Corryton Utility District	Union	Surface Water
Maynardville Water Department	Union	Groundwater UDI Surface water
Sharps Chapel School	Union	Groundwater UDI Surface water

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Chapter 4 DRINKING WATER

Oversight of Free Residual Chlorine and Bacteriological Sampling of Oak Ridge Reservation Sanitary Water Distribution Systems

Principal Author: Kathleen Kitzmiller

Abstract

As the three Department of Energy (DOE) Oak Ridge Reservation (ORR) plants become more accessible to the public, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) has expanded its oversight of the DOE facilities' safe drinking water programs. The scope of TDEC DOE-O independent sampling includes oversight of potable water quality on or impacted by the ORR. TDEC conducted oversight of total coliform bacteria and free residual chlorine sampling at various buildings on the DOE ORR. Oversight of routine, monthly sampling activities allowed TDEC personnel to become familiar with site potable water contacts in each plant's utility organization or subcontractor. In conjunction with these oversight activities, TDEC took independent samples of free chlorine residuals during site visits to monitor monthly sampling activities.

Introduction

Public consumption of the water on the Oak Ridge Reservation (ORR) continues to increase. In order to facilitate technology transfer, work for non-governmental sectors, and utilization of surplus buildings by private companies, security has been relaxed or reprioritized in recent years at some portions of the sites, most notably at East Tennessee Technology Park (ETTP). In turn the composition of the workforce at the ORR has changed substantially. Oak Ridge National Laboratory (ORNL) has always hosted foreign dignitaries and accommodated visiting scientists in an openly cooperative manner. The other two sites, ETTP and Y-12, until recently allowed only limited public visitation. Current facility use involves a substantial public presence at ETTP and ORNL, and to a lesser extent at Y-12.

During May 2000, Department of Energy (DOE) transferred the Y-12 water treatment plant to the city of Oak Ridge. Both the ETTP and the former Y-12 water treatment plants withdraw surface water from the Clinch River, add coagulants to precipitate suspended sediment, use chlorine disinfectant, and filter water prior to distribution. As prescribed by *Tennessee Regulations for Public Water Systems and Drinking Water Quality - Chapter 1200-5-1*, most sampling focuses upon finished water at the treatment plant prior to distribution. State regulations require relatively little sampling at locations within distribution systems. The ORR potable water systems have been classified as non-community, non-transient systems. *Rule 1200-5-1-.07(1)(d)(3)* states that non-community water systems using surface water must monitor for total coliforms with the frequency required of like-sized community water systems. *Rule 1200-5-1-.31(5)(c)(3)* directs that residual disinfectant concentration be measured at the same times and locations that monthly microbiological contaminant samples are collected. Requirements set forth by *Rule 1200-5-1-.17(4)* mandate that not more than five percent of samples taken each month for two consecutive months contain less than 0.2 mg/L free chlorine residual. Shown below (Table 1) is the minimum number of bacteriological samples required for each of the DOE distribution systems set forth by the sanitary surveys in effect for calendar year 2001.

Table 1. ORR Plant Populations and Required Samples

Facility	Estimated Population	Minimum Samples
ETTP	2,000	2
ORNL	5,000	6
Y-12	5,080	7

Methods and Materials

Although TDEC will conduct independent sampling when situations indicate that the quality of drinking water in an ORR distribution system may be compromised or that the general integrity of the system is in doubt, the objective of this task was to conduct oversight of routine regulatory bacteriological and free residual chlorine monitoring at ETTP, ORNL, and Y-12. Coliform bacteria serve to indicate the presence of pathogenic organisms. A positive microbiological sample signals that pathogens may have entered the water supply due to inadequate initial treatment, poor sanitation, faulty line repair work, or cross connections to potable water distribution lines. During calendar year 2001, at the direction of Division management, TDEC personnel collected independent bacteriological samples from three buildings at ORNL. The buildings were located at far reaches of the distribution system. Potable water delivered to these sites was expected to contain relatively low levels of free residual chlorine. The samples, analyzed by the Knoxville Branch Laboratory, tested negative for microbiological contamination. TDEC did not observe conditions in ORR distribution systems that warranted additional collection of independent bacteriological samples, and instead focused upon sampling for free residual chlorine only. TDEC used a Hach pocket colorimeter to measure free residual chlorine levels at all three facilities. Monitoring followed Method 4500-Cl G, DPD Colorimetric Method, outlined in the *Standards Methods for the Examination of Water and Wastewater, 20th Edition.* One of two small sample containers is reserved for a sample blank. A reagent, DPD powder, is added to the remaining container. The powder reacts with free chlorine present in the drinking water sample. A slight free chlorine residual results in a pale pink hue, whereas a high chlorine residual produces a deep cranberry color. The colorimeter then measures the concentration of free chlorine in the sample.

Bound logbooks, databases, and trip reports serve collectively to document TDEC's potable water oversight activities.

Results and Discussion

Thirty-two visits were made to oversee monthly bacteriological and free chlorine residual sampling. TDEC sampling for free residual chlorine was done using TDEC's colorimeter. Table 2 summarizes the sampling results.

Table 2. Oversight Visits - Observation of Monthly Sampling

Date of Visit	ORR Facility	Number of Bacteriological Samples Contractor	Lowest Free Chlorine Residual Contractor/TDEC (mg/L)
01/08/01	ORNL	3	0.93/0.98
01/10/01	Y-12	7	0.3/0.32
01/16/01	ORNL	3	1.14/1.09
02/12/01	ORNL	3	0.98/0.78
02/13/01	Y-12	7	0.4/0.67
03/05/01	ORNL	3	0.59/0.63
03/06/01	Y-12	7	0.9/1.26
03/12/01	ORNL	3	0.87/0.79
04/02/01	ORNL	3	0.70/0.64
04/09/01	ORNL	3	0.86/0.37
04/10/01	Y-12	7	0.7/1.03
05/07/01	ORNL	3	0.24/0.28
05/08/01	Y-12	7	0.6/0.79
05/14/01	ORNL	3	0.73/0.72
06/04/01	ORNL	3	0.49/0.39
06/11/01	ORNL	3	0.98/0.74
06/12/01	Y-12	7	0.2/0.29
07/02/01	ORNL	3	0.44/0.36
07/09/01	ORNL	3	0.77/0.67
07/11/01	ETTP	2	0.36/0.33
08/06/01	ORNL	3	0.58/0.54
08/13/01	ORNL	3	0.95/0.85
08/21/01	Y-12	7	0.5/0.55
09/10/01	ORNL	3	0.81/0.87
10/01/01	ORNL	3	0.59/0.52
10/08/01	ORNL	3	0.89/0.91
10/16/01	ETTP	2	0.8/0.33
11/05/01	ORNL	3	0.61/0.71
11/13/01	ETTP	2	0.9/1.55
12/03/01	ORNL	3	0.78/0.64
12/10/01	ORNL	3	0.99/0.86
12/12/01	Y-12	7	0.3/0.54

Conclusion

As can be seen in Table 2 no samples collected by the contractor or TDEC indicated chlorine levels to be below the regulatory limit of 0.2 mg/L. Also, there were no samples reported to have elevated levels of bacteria above the regulatory limits. TDEC will continue to monitor the sample collection activities and if conditions warrant will collect free chlorine and/or bacteriological samples for comparisons.

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Chapter 4 DRINKING WATE R

Special Projects

Principal Author: Kathleen Kitzmiller

Abstract
During the calendar year 2001, projects arose that were not covered under existing monitoring plans. These special projects allow for increased opportunities to monitor and evaluate Department of Energy (DOE) water system operations. They included two water studies stemming from the East Tennessee Technology Park (ETTP) Water Quality Project.

Introduction
Special projects provide opportunities for the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) to further evaluate the operation and condition of water systems on the Oak Ridge Reservation (ORR) and to aid in regulatory compliance efforts. During the previous year, TDEC focused upon two studies pertaining to the (ETTP) Water Quality Project.

- EPA Test Results for the Phase 1 Water Study of ETTP
- Phase 2 Water Study of ETTP

Discussion
EPA Test Results for the Phase 1 Water Study of ETTP. The Phase 1 Water Study focused upon concerns about the current safety of drinking water at ETTP. Drinking water samples were collected during August 2000 from nineteen sites, including the water treatment plant. These sites were selected for sampling in order to include areas where worker populations are present, areas at the far reaches of the distribution system, and areas of concern identified by current and former workers. The EPA collected replicate samples at seven of the drinking water sites. In order to ascertain potential impact upon the drinking water distribution system in the event of cross-connections, firewater was sampled at six locations. Raw water from the Clinch River was also sampled.

Laboratory analyses for the Phase 1 sampling effort were completed by early September 2000. The analyses found levels of iron and manganese in excess of secondary maximum contaminant levels (SMCLs) at one drinking water site and one fire water site. SMCLs pertain to aesthetic – taste, color, odor, etc. – rather than health concerns. A comprehensive final report, *Special East Tennessee Technology Park Water Sampling Report,* was released in early November.

In January, the EPA released test results for its tap water samples collected the previous August at seven ETTP buildings. The National Air and Radiation Laboratory ran analyses for radionuclides (isotopic uranium, gamma, and gross alpha/beta), and for inorganic metals. According to its preliminary review of its data, the EPA “has not identified any results inconsistent with those issued by DOE for the tap water sampling event.”

Phase 2 Water Study of ETTP. Phase 2 of the ETTP Water Quality Project focused upon the history of the ETTP drinking water system and the likelihood of worker health effects due to consumption of water at the plant in the past. DOE/ORO requested that DOE-O participate in an oversight group, the Community Input Team (CIT), similar in composition to that formed for the Phase I Water Study. DOE hired Parallax, Inc., to facilitate the Phase 2 Water Study. The JSI Center for Environmental Health Studies, TerraGraphics Environmental Engineering, and Malcolm Pirnie, Inc., comprised the project team.

Members of the Phase II study team from JSI, TerraGraphics, and Malcom Pirnie conducted a site visit of ETTP during the first two weeks of February. The study team finalized the task plan and work breakdown structure of the project. Four tasks made up the work plan. For the first three tasks, an interim technical memorandum was to summarize findings and recommend actions for the succeeding task.

- Task 1 – Identify contaminants and routes of exposure, and the timeframes of operational eras.
- Task 2 – Determine whether quantitative or qualitative exposure assessments can be done, and develop estimates of contaminant concentrations in the water systems.
- Task 3 – Estimate worker exposures and assess potential health impacts.
- Task 4 – Review stakeholder comments, incorporate appropriate revisions, and publish a final report.

During the site visit, project team members began the process of identification and review of plant records and documents. They met with individuals knowledgeable about past operations. Project team members, along with several CIT representatives including DOE-O personnel, also toured sites related to systems for re-circulating cooling water, firewater, sanitary water treatment and distribution, sanitary sewers and sewage treatment, storm water, and steam production and distribution.

A public meeting was held during April at which project team representatives introduced the proposed work plan, presented initial assumptions underlying the plan, and sought public input. In late April the project team reported that it had inventoried a number of water additives, comprising roughly fifty chemicals, to be evaluated for toxicity. The Task 1 report, due June 30, would note which of these had been identified as chemicals of concern. Engineering drawings of ETTP water systems were being examined. More than 150 documents had been reviewed. By mid-June, over 600 documents had been compiled and were being reviewed. Most of the eighty-one engineering drawings of the sanitary water system had been digitized as a prelude to hydraulic modeling. The team continued to evaluate the previously identified water additives for toxicity. The distribution date for the Task 1 draft report was pushed back until mid-July.

Team members of the ETTP Water Quality Project met onsite in July to resolve questions pertaining to water system drawings and historical documents. The release of the team's first technical memorandum was further postponed until late August. The Task 1 draft report was distributed to CIT members in late August. The CIT met in September to critique the draft report and suggested a number of improvement items. However, the project team had exhausted its budget without completing even the first of its milestones. Future funding for completion of the Phase 2 Water Study appeared uncertain. As of November, the project remained on hold. Subsequently, DOE halted further investigation, noting that the study had accomplished all that could reasonably

be achieved, having identified chemicals of concern and potential pathways to employees. Given the lack of sufficient data about historical operations, further analysis would not be likely to yield additional findings of significance.

Conclusion

The special projects described above, EPA test results for the Phase 1 Water Study of ETTP and the Phase 2 Water Study of ETTP, allowed for increased opportunities to monitor and evaluate DOE water system operations.

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Chapter 4 DRINKING WATER

Implementation of EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Drinking Water Program (RMO)

Principal Author: John Sebastian

Abstract

The Environmental Radiation Ambient Monitoring System was developed by the U.S. Environmental Protection Agency (EPA) to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources (U.S. EPA, 1988). This program provides for radiochemical analysis of finished water at five public water supplies located near and on the Oak Ridge Reservation. In this effort, quarterly samples are taken by personnel from the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division to be analyzed at the EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. While data from the program indicate tritium results have been consistently higher for the Gallaher Water Treatment Plant than the four other systems monitored in the program, all the results received from EPA, to date, have been well below regulatory criteria.

Introduction

Radioactive contaminants released on the Oak Ridge Reservation (ORR) enter local streams and are transported to the Clinch River. While monitoring of these streams, the river, and local water treatment facilities has indicated that concentrations of radioactive pollutants are below regulatory standards, there has remained a concern that area public water supplies could be impacted by ORR pollutants. In 1996, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division began participation in the Environmental Protection Agency's (EPA) Environmental Radiation Ambient Monitoring Systems (ERAMS). This program provides radiological monitoring of finished water at public water supplies near nuclear facilities throughout the United States. The ERAMS program is designed to:

1. Monitor pathways for significant population exposure from routine and/or accidental releases of radioactivity;
2. Provide data indicating additional sampling needs or other actions required to ensure public health and environmental quality;
3. Serve as a reference for data comparison (U.S. EPA, 1988).

The ERAMS program also provides a mechanism to evaluate the impact (if any) of DOE activities on area water systems and validate DOE monitoring in accord with the *Tennessee Oversight Agreement* (TDEC, 1996).

Methods and Materials

In the Oak Ridge ERAMS Program, EPA provides radiochemical analysis of finished drinking water samples taken quarterly by TDEC staff at five public water supplies located on and in the vicinity of the ORR. Samples are collected using procedures and supplies prescribed in *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988). The five Oak Ridge area monitoring locations are: Kingston Water Treatment Plant, Gallaher (K-25)

Water Treatment Plant, West Knox Utility, city of Oak Ridge (Y-12) Water Treatment Facility, and Anderson County Utility District. ERAMS analysis is performed at EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. Analytical frequencies and parameters are provided in Table 1.

Table 1: ERAMS Analysis for Drinking Water

ANALYSIS	FREQUENCY
Tritium	Quarterly
Gamma Scan	Annually on composite samples
Gross Alpha	Annually on composite samples
Gross Beta	Annually on composite samples
Iodine-131	Annually on one individual sample/sampling site
Radium-226	Annually on samples with gross alpha >2 pCi/L
Radium-228	On samples with Radium-226 between 3-5 pCi/L
Strontium-90	Annually on composite samples
Plutonium-238, Plutonium-239, Plutonium-240	Annually on samples with gross alpha >2 pCi/L
Uranium-234, Uranium-235, Uranium-238	Annually on samples with gross alpha >2 pCi/L

Results and Discussion

A large proportion of the radioactive contaminants that are transported off the ORR in surface water enter the Clinch River by way of White Oak Creek, which drains the Oak Ridge National Laboratory complex and associated waste disposal areas. When contaminants carried by White Oak Creek and other ORR streams enter the Clinch, their concentrations are significantly lowered by the dilution provided by the waters of the river. With exceptions, contaminant levels are further reduced in finished drinking water by conventional water treatment practices used by area utilities. Consequently, the levels of radioactive contaminants measured in the Clinch and at area water supplies are far below the concentrations measured in White Oak Creek and some of the other streams on the ORR.

Since the Gallaher Water Treatment Plant is the closest water supply downstream of White Oak Creek (approximately 6.5 River Miles), this facility would be expected to exhibit the highest concentrations of radioactive contaminants of the five utilities monitored in the program. Conversely, the Anderson County Facility (located upstream of the reservation) would be expected to be the least vulnerable of the facilities to ORR pollutants.

While analysis of ERAMS samples for 2001 have yet to be completed, the recently received results for tritium and iodine-131 were all well below applicable drinking water standards (Tables A.1 and A.2 in Appendix A). As in the past, results reported for tritium (a radionuclide not removed by conventional treatment processes) are higher for the Gallaher facility. While consistently higher than the concentrations measured at the other facilities, the results for tritium reported for the Gallaher plant were all well below standard prescribed by the Safe Drinking Water Act. In this regard, the Safe Drinking Water Act specifies that the annual average concentration of tritium in community drinking water systems not exceed 20,000 pCi/L. The average concentration of tritium measured at the Gallaher facility for 2001 was 252 pCi/L (Figure 1), which is down from an average of 548 pCi/L reported in 2000.

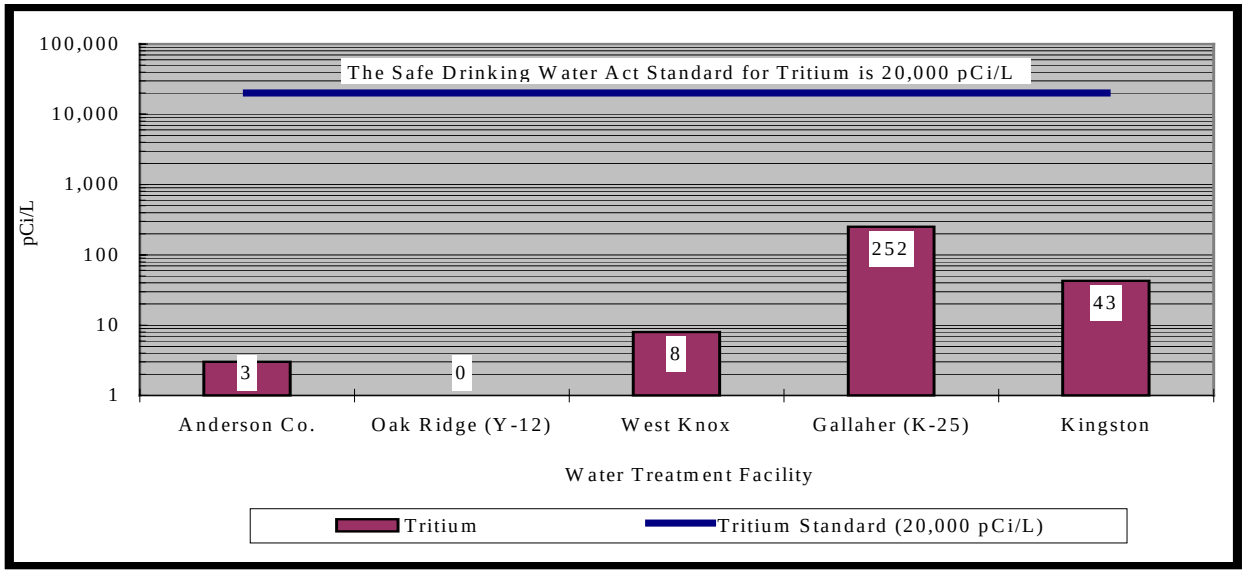

Figure 1: Average Tritium Results for 2001 for Samples of Finished Drinking Water taken at Oak Ridge Area Water Treatment Facilities in association with EPA's ERAMS Program

Conclusion

Radioactive contaminants migrate from the ORR to the Clinch River, which serves as a raw water source for area public drinking water supplies. The impact of these contaminants is diminished by dilution provided by waters of the Clinch. Contaminant concentrations are further reduced in finished drinking water by conventional water treatment practices employed by area utilities. In 2001, ERAMS results reported for iodine-131 and tritium were all well below drinking water criteria. While below drinking water standards, tritium was reported at higher levels in samples taken from the Gallaher Water Treatment Facility than the other facilities monitored in the program. In this respect, the Gallaher plant is the closest facility downstream of White Oak Creek, the major pathway for radiological pollutants entering the Clinch from the ORR. Although gross alpha, gross beta, and gamma spectroscopy results were unavailable at the time of publication, it is expected that these results will be similar to those of previous years (i.e., well below drinking water standards).

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Appendix A: ERAMS Tritium and Iodine-131 Results for Year 2001 Samples of Finished Drinking Water taken at Oak Ridge Area Water Treatment

Table A.1: 2001 ERAMS Tritium Results for Drinking Water in the Oak Ridge Area

Water Treatment Facility	Collection Date	Activity (pCi/L)	Error (+/- 2 σ) (pCi/L)	MDC[a] (pCi/L)	Standard[b] (pCi/L)
Anderson Co.	03/08/01	30	73	124	20,000
Anderson Co. Dup.[c]	03/08/01	17	73	124	20,000
Anderson Co.	05/04/01	0	76	129	20,000
Anderson Co.	08/09/01	-7	81	139	20,000
Anderson Co.	10/17/01	-13	77	133	20,000
Gallaher (K-25)	02/26/01	658	99	125	20,000
Gallaher (K-25)	05/21/01	271	92	139	20,000
Gallaher (K-25)	08/17/01	-15	81	139	20,000
Gallaher (K-25)	10/18/01	96	82	133	20,000
Kingston	02/26/01	16	73	124	20,000
Kingston	05/04/01	137	82	130	20,000
Kingston	08/09/01	-11	81	140	20,000
Kingston	10/26/01	29	79	133	20,000
West Knox	02/22/01	-5	72	124	20,000
West Knox	05/04/01	18	77	130	20,000
West Knox	08/09/01	15	82	140	20,000
West Knox	10/26/01	2	77	132	20,000
Oak Ridge (Y-12)	02/22/01	-17	72	124	20,000
Oak Ridge (Y-12)	05/04/01	81	80	130	20,000
Oak Ridge (Y-12)	08/09/01	-88	78	140	20,000
Oak Ridge (Y-12)	10/30/01	-31	75	132	20,000

[a]Minimum Detectable Concentration
[b]40 CFR Part 141—National Primary Drinking Water Regulations.
[c]Duplicate analysis

Table A.2: 2001 ERAMS Iodine-131 Results for Drinking Water in the Oak Ridge Area

Water Treatment Facility	Collection Date	Activity (pCi/L)	Error (+/- 2 σ) (pCi/L)	MDC[a] (pCi/L)	Standard[b] (pCi/L)
Anderson Co.	03/08/01	0.01	0.14	0.24	3.0
Gallaher (K-25)	10/18/01	-0.1	0.18	0.31	3.0
Kingston[c]					3.0
Oak Ridge (Y-12)	02/22/01	0.01	0.16	0.26	3.0
West Knox	02/22/01	0.08	0.17	0.27	3.0

[a] Minimum Detectable Concentration
[b] The Safe Drinking Water Act prescribes beta and photon emitters in drinking water not exceed an annual dose equivalent of 4 mrem/year. The values referenced represent annual average concentrations yielding 4 millirem per year for a two liter daily intake from Appendix III in *Radioactivity in Drinking Water* (EPA, 1991).
[c]The iodine-131 result for the Kingston Facilities was not reported in the ERAMS data received to date

Chapter 5 AIR QUALITY MONITORING

Hazardous Air Pollutants Metals Monitoring on East Tennessee Technology Park

Principal Author: Randy Meyer

Abstract

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division's (DOE-O) Hazardous Air Pollutant (HAPs) Monitoring Program was developed to provide continued independent monitoring at the East Tennessee Technology Park (ETTP) and to verify the Department of Energy's (DOE) reported monitoring results. Monitoring was conducted for Arsenic, Beryllium, Cadmium, Total Chromium, Lead, Nickel, and Uranium as a metal. In order to ensure conservative values, detection limits were utilized when averaging results below the detection limits of the laboratory analysis except for Background Data.

As a result of this monitoring campaign conducted by TDEC at the ETTP sites, analytical results indicate no apparent elevated levels of HAPs metals of concern. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis. Background levels, collected near Norris Lake were slightly lower than samples on the ETTP. This would be expected when comparing an industrialized area to a more remotely located residential area. In keeping with this premise, it should also be noted that other incinerator facilities are in the general vicinity of the Oak Ridge Reservation (ORR). The possibility exists that these operations, along with the Tennessee Valley Authority (TVA) Bull Run Steam Plant facility on Edgemoor Road and the Kingston Steam Plant could have an impact on the ambient air around the ORR. Operations at the Toxic Substance Control Act (TSCA) Incinerator cannot be singled out as the sole contributor of levels seen in the analytical results from the ETTP or the ORR in general.

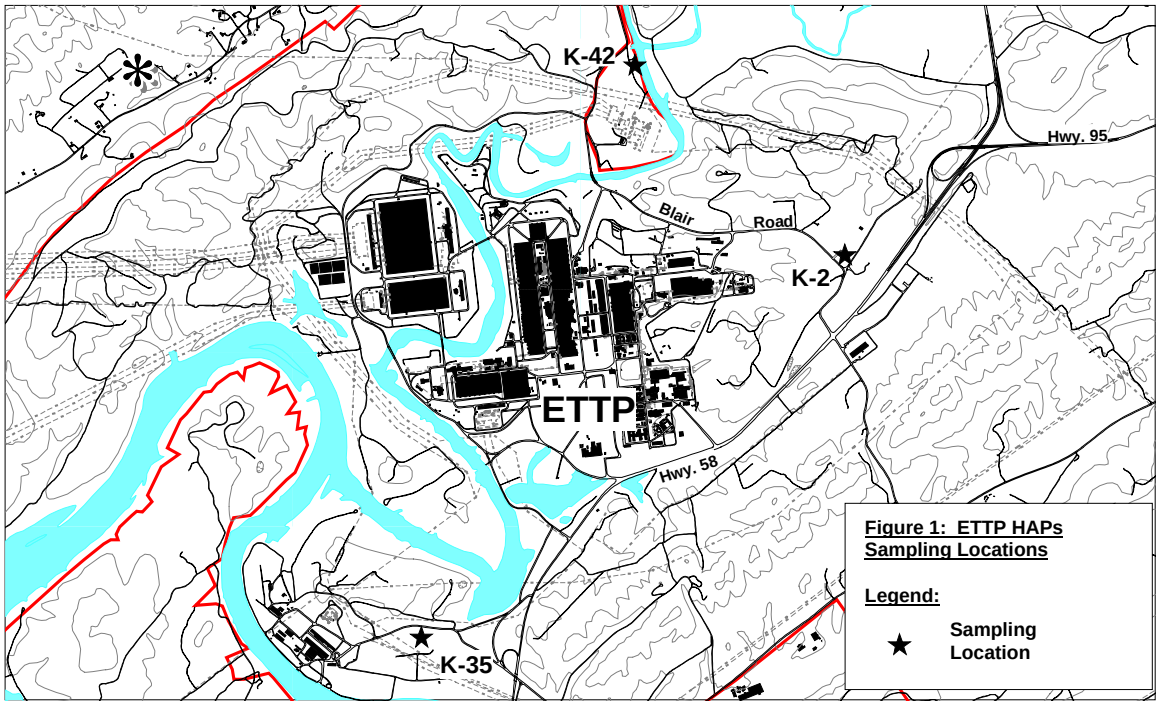
Future D&D activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by TDEC.

This project will continue to monitor for potential effects on the ORR at ETTP in order to provide independent monitoring to assure protection of human health and the environment.

Introduction

In 1997, concerns were raised by members of the public regarding potential health effects due to possible concentrations of Hazardous Air Pollutants (HAPs) in the ambient air on and around the Oak Ridge Reservation (ORR). In response to these concerns, the Tennessee Department of Environment and Conservation's (TDEC's), Department of Energy Oversight Division (DOE-O), Waste Management (WM) program developed an ambient air monitoring program for the ORR in order to determine what effects, if any, Department of Energy (DOE) operations were having on the ambient air on and around the reservation with regard to HAPs. This program was designed to provide an independent verification of monitoring results as reported by the DOE. Background data was collected at a site located near Norris Lake. This data was used in a comparative manner as a baseline for the area surrounding the ORR. Nickel and Uranium as a metal were added in 1999 to the list of metals of concern. Future Decontamination and

Decommissioning (D&D) activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by TDEC.



ETTP

Monitoring for this project was conducted at Stations K-2 (Blair Rd opposite the TSCA Incinerator - 1), Perimeter Air Monitor Station 42 (next to Poplar Creek) and Perimeter Air Monitor Station 35 (Gallaher Rd Bridge area). See Figure 1. These sites were also utilized for the 1999 and 1998 campaigns.

Methods and Materials

The monitoring sites selected were chosen based upon windroses data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The windflow during the day is a southwest to northeast pattern while during the night; the flow pattern is reversed. The placement then of TDEC's monitors allowed for sampling that would be representative of a 24-hour windflow pattern at the ORR.

The project was conducted as closely as possible to the currently established 2001 sampling project schedule. This schedule was modified as needed to accommodate numerous power outages caused by construction near the K42 site, and other events that effected movement of the samplers. Filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis.

Materials required for this project included:

1. Hi-Volume sampler
2. Trailer
3. Extension cords
4. 4x4 vehicle
6. Calibration kit
7. Flow chart
8. Level
9. Project data form

5. Filters

Results and Discussion

Background Results

A site was located in Norris, Tennessee, near Norris Lake, in a residential area. This site was monitored during the periods of 4/7-5/21, and 6/23-7/14 1999. The results are shown in Table 1.

Table 1. Background/Norris

Metal of Concern	1999 Sample result µg/m^3	Guideline Concentration µg/m^3
Arsenic	Undetected	0.0023 [1]
Beryllium	Undetected	0.004 [1]
Cadmium	Undetected	0.0056 [1]
Total Chromium	< 0.001	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	Undetected	1.5 [2]
Nickel	Undetected	0.042[1]
Uranium	Undetected	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

Results from ETTP

HAPs metals were monitored at the K-2 station during the time periods of 1/01-1/04, 3/13-5/30, and 09/27-11/08 2001. The results are shown in Table 2.

Table 2. HAPs K2 Sampling Results

Metal of Concern	2001 Results µg/m^3	2000 Results µg/m^3	1999 Results µg/m^3	1998 Results µg/m^3	Guideline Concentration µg/m^3
Arsenic	ND	ND	< 0.01	ND	0.0023 [1]
Beryllium	ND	ND	< 0.001	ND	0.004 [1]
Cadmium	ND	ND	< 0.001	ND – 0.0004	0.0056 [1]
Total Chromium	< 0.001	< 0.001	< 0.0013	0.0007 – 0.001	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	0.0048	0.0034	0.0026	0.006 – 0.002	1.5 [2]
Nickel	ND	< 0.001	< 0.001	No sampling	0.042[1]
Uranium	ND	ND	< 0.01	No sampling	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

The monitor was co-located with DOE Perimeter Air Monitor (PAM) Station K42 – TSCAI. HAPs metals were monitored at K-42 during the time periods of 2/13-3/13, 11/08-12/31 2001.

The results are shown in Table 3.

Table 3. HAPs K42 Sampling Results

Metal of Concern	2001 Results µg/m^3	2000 Results µg/m^3	1999 Results µg/m^3	1998 Results µg/m^3	Guideline Concentration µg/m^3
Arsenic	ND	ND	< 0.01	ND – 0.03	0.0023 [1]
Beryllium	ND	ND	< 0.001	ND - 0.0002	0.004 [1]
Cadmium	ND	ND	< 0.001	ND – 0.0001	0.0056 [1]
Total Chromium	ND	< 0.001	< 0.0013	0.0009 – 0.001	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	0.0026	0.0028	0.0026	ND- 0.05	1.5 [2]
Nickel	< 0.001	< 0.001	< 0.001	No sampling	0.042[1]
Uranium	ND	ND	< 0.01	No sampling	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

The monitor was co-located with DOE Perimeter Air Monitor (PAM) Station 35 – TSCA2. HAPs metals were monitored at K-35 during the time periods of 1/04-2/13, 6/28-9/20 2001. The results are shown in Table 4.

Table 4. HAPs K35 Sampling Results

Metal of Concern	2001 Results µg/m^3	2000 Results µg/m^3	1999 Results µg/m^3	1998 Results µg/m^3	Guideline Concentration µg/m^3
Arsenic	ND	ND	< 0.01	ND	0.0023 [1]
Beryllium	ND	ND	< 0.001	ND	0.004 [1]
Cadmium	ND	ND	< 0.001	ND	0.0056 [1]
Total Chromium	<0.001	<0.001	< 0.005	0.001	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	0.0045	0.0044	< 0.0015	ND-0.001	1.5 [2]
Nickel	ND	< 0.001	< 0.001	No sampling	0.042[1]
Uranium	ND	ND	< 0.01	No sampling	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

Levels of Total Chromium were compared to the Risk Specific Dose levels for Hexavalent Chromium at the following monitoring locations: K2, K35, and K42.

As Hexavalent Chromium is a fractional constituent of Total Chromium, it is highly unlikely that these levels of Total Chromium would translate into elevated levels of Hexavalent Chromium. These results are consistent with previous sampling efforts. For those monitoring locations at ETTP, observed levels of Total Chromium could possibly be attributed to the ongoing decommissioning and decontamination activities related to reindustrialization at the ETTP site.

Based upon the analytical data generated at these monitoring sites, it would appear that there has been no significant change in levels of any metals of concern in the ambient air on and around these sampling points at the ETTP. Background levels, collected near Norris Lake were slightly lower than samples on the ETTP. This would be expected when comparing an industrialized area to a more remotely located residential area.

This project has been re-authorized to continue into 2002. Sampling sites will remain as they have for the year 2001. Future D&D activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by TDEC.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2001 was not available. However, analytical results from the 1998, 1999 and 2000 HAPs monitoring program were compared with the 2000 ASER, indicating comparable levels of HAPs in the ambient air in and around the ORR.

Conclusion

As a result of the 2001 monitoring campaign conducted by TDEC at the ETTP sites, analytical results indicate no apparent elevated levels of HAPs metals of concerns. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis.

It should also be noted that other incinerator facilities are in the vicinity of the ORR. The possibility exists that these operations, along with the TVA Bull Run Steam Plant facility on Edgemoor Road and the Kingston Steam Plant could have an impact on the ambient air around the ORR. Operations at the TSCA Incinerator cannot be singled out as the sole contributor of levels seen in the analytical results from the ETTP or the ORR in general.

References

Draft New York State Air Guide-1, Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

Boiler and Industrial Furnace Regulations - 40 CFR Part 266 Appendix V.

Yard, C.R. 2001 *Health, Safety and Security Plan*, Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge, Tennessee

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

Chapter 5 TDEC/DOE-O Procedure number: SOP-ES&H-004 Air Monitoring/Air Sampling

Chapter 5 AIR QUALITY MONITORING

Hazardous Air Pollutants Metals Monitoring on Y-12 and ORNL (X-10)

Principal Author: Randy Meyer

Abstract

The Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight Division's (DOE-O) Hazardous Air Pollutant (HAPs) Monitoring Program was expanded in 1999 to include ORNL (X-10) and Y-12.

This program at East Tennessee Technology Park (ETTP) was designed to provide continued independent monitoring at the Oak Ridge Reservation (ORR) and to verify the Department of Energy (DOE) reported monitoring results. Monitoring was conducted for Arsenic, Beryllium, Cadmium, Total Chromium, Lead, Nickel and Uranium as a metal. In order to ensure conservative values, detection limits were utilized when averaging results below the detection limits of the laboratory analysis except for Background Data.

As a result of this monitoring campaign conducted by TDEC at the ORR sites, analytical results indicate no apparent elevated levels of HAPs metals of concern. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis. Background levels, collected near Norris Lake were slightly lower than samples on the ORR. This would be expected when comparing an industrialized area to a more remotely located residential area. In keeping with this premise, it should also be noted that other incinerator facilities are in the general vicinity of the ORR. The possibility exists that these operations, along with the Tennessee Valley Authority (TVA) Bull Run Steam Plant facility on Edgemoor Road and the Kingston Steam Plant could have an impact on the ambient air around the ORR.

This project will continue to monitor for potential effects on the ORR in order to provide independent monitoring to assure protection of human health and the environment.

Introduction

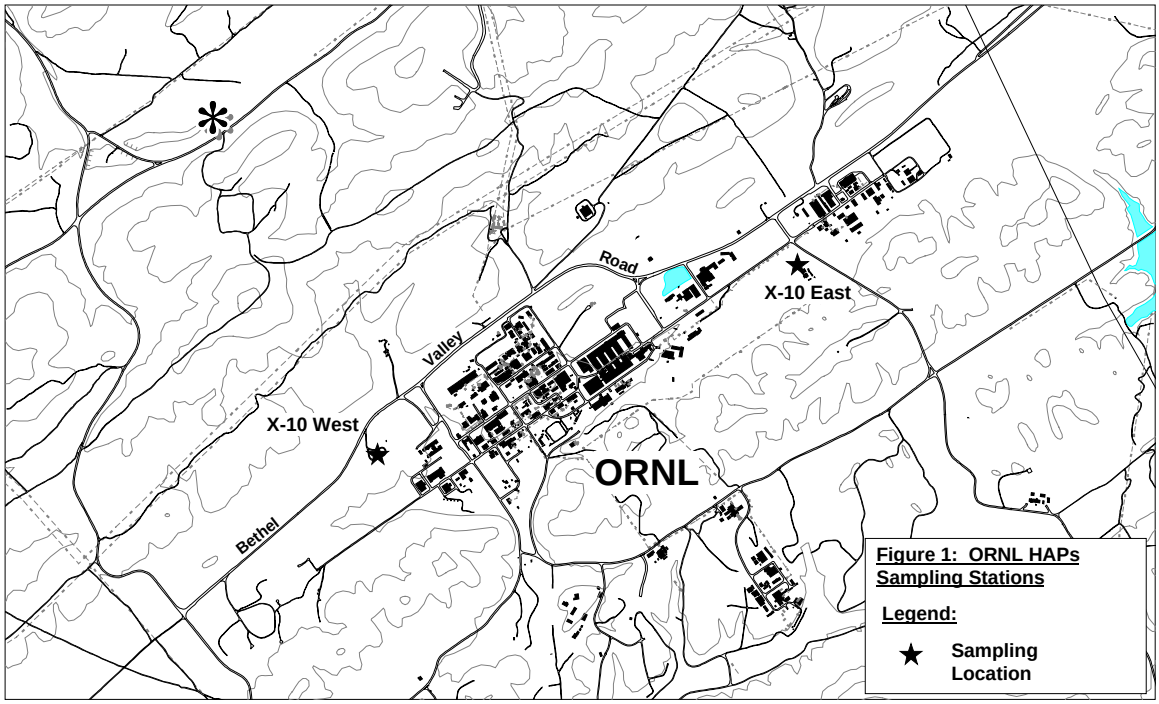
In 1999, the Tennessee Department of Environment and Conservation's (TDEC's), Department of Energy Oversight Division (DOE-O) Hazardous Air Pollutant's (HAPs) Monitoring Program was expanded to include Oak Ridge National Laboratory (ORNL) (X-10) and Y-12.

This program at East Tennessee Technology Park (ETTP) was designed to monitor concentrations of HAPs in the ambient air on and around the Oak Ridge Reservation (ORR), and to provide an independent verification of monitoring results as reported by the DOE. Background data was collected at a site located near Norris Lake. This data was used in a comparative manner as a baseline for the area surrounding the ORR. In 1999 Nickel and Uranium as a metal were added to the list of metals of concern.

Each monitoring site was co-located with ORR meteorological towers, perimeter air monitoring stations or an Environmental Radiation Ambient Monitoring Systems (ERAMS) monitoring station.

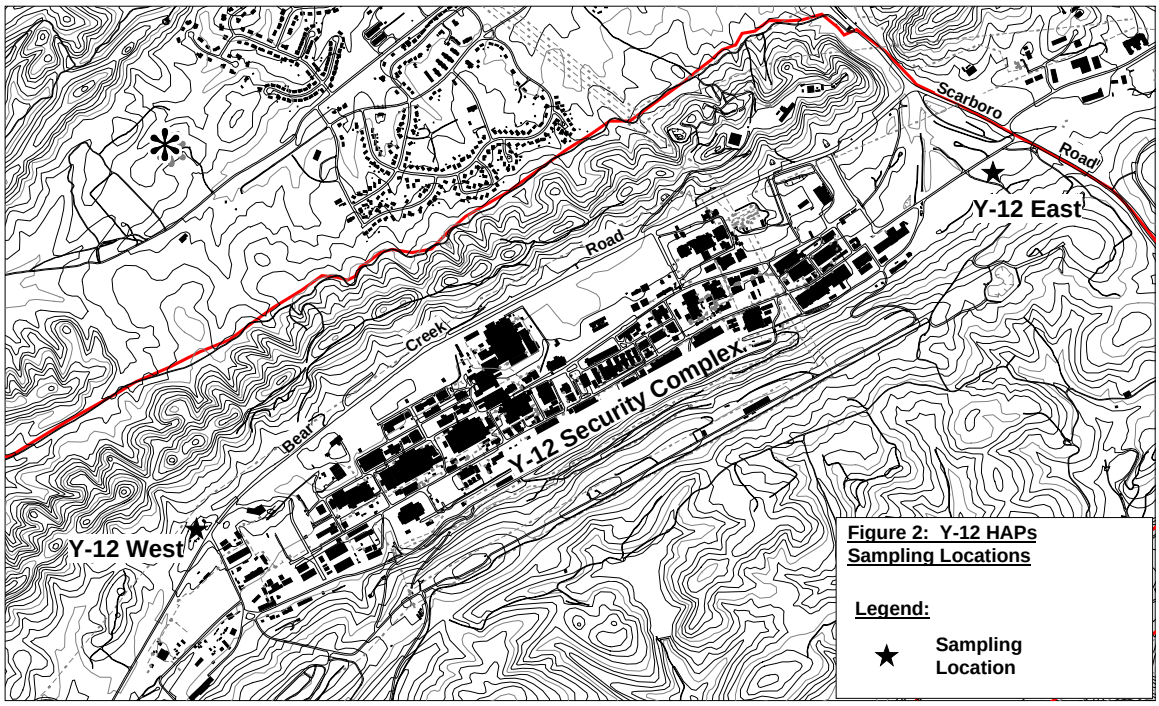
ORNL

Monitoring at ORNL was conducted at stations located at both the east and west ends of this facility. The western site is co-located at the Perimeter Air Monitor (PAM) 3 off Bethel Valley Road. The monitor at the east-end of ORNL is co-located with Meteorological Tower 3. See Figure 1.



Y12

Monitoring at Y-12 was conducted at stations located at both the east and west ends of this facility. The site at the west-end of Y-12 is co-located with Meteorological Tower 6 on Bear Creek Valley Road. The monitoring site at the east-end of Y-12 is co-located with Meteorological Tower 5. See Figure 2.



Methods and Materials

The monitoring sites selected were chosen based upon windroses data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The windflow during the day is a southwest to northeast pattern while during the night; the flow pattern is reversed. The placement then of TDEC's monitors allowed for sampling that would be representative of a 24-hour windflow pattern at the ORR. The project was conducted as closely as possible to the currently established 2001 sampling project schedule. Filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis.

Materials required for this project included:

1. Hi-Volume sampler
2. Trailer
3. Extension cords
4. 4x4 vehicle
5. Filters
6. Calibration kit
7. Flow chart
8. Level
9. Project data form

Results and Discussion

Background Results

A site was located in Norris, Tennessee, near Norris Lake, in a residential area. This site was monitored during the periods of 4/7-5/21, and 6/23-7/14 1999. The results are shown in Table 1.

Table 1. Background/Norris

Metal of Concern	1999 Sample result μg/m^3	Guideline Concentration μg/m^3
Arsenic	Undetected	0.0023 [1]
Beryllium	Undetected	0.004 [1]
Cadmium	Undetected	0.0056 [1]
Total Chromium	< 0.001	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	Undetected	1.5 [2]
Nickel	Undetected	0.042[1]
Uranium	Undetected	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

Results from X10 (ORNL)

HAPs metals were monitored at station X10W through the periods of 1/4-4/18, 7/10-9/14 2001. The results are shown in Table 2.

Table 2. HAPs X10W Sampling Results

Metal of Concern	2001 Results μg/m3	2000 Results μg/m3	1999 Results μg/m3	Guideline Concentration μg/m3
Arsenic	ND	ND	< 0.01	0.0023 [1]
Beryllium	ND	ND	< 0.001	0.004 [1]
Cadmium	ND	ND	< 0.001	0.0056 [1]
Total Chromium	< 0.001	< 0.001	0.0016	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	0.0033	0.0042	0.0056	1.5 [2]
Nickel	< 0.001	< 0.001	< 0.0011	0.042[1]
Uranium	ND	ND	< 0.01	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

HAPs metals were monitored at station X10E through the periods 1/1-1/4, 4/18-7/10, 9/14-12/31 2001. The results are shown in Table 3.

Table 3. HAPs X10E Sampling Results

Metal of Concern	2001 Results μg/m^3	2000 Results μg/m^3	1999 Results μg/m^3	Guideline Concentration μg/m^3
Arsenic	ND	ND	< 0.01	0.0023 [1]
Beryllium	ND	ND	< 0.001	0.004 [1]
Cadmium	ND	ND	< 0.001	0.0056 [1]
Total Chromium	ND	< 0.00061	0.0008	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	0.0032	0.0034	0.0031	1.5 [2]
Nickel	ND	< 0.001	0.001	0.042[1]
Uranium	ND	ND	< 0.01	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

Results from Y12

HAPs metals were monitored at stationY12E through the periods 1/4-2/5, 3/13-5/30, 8/14-11/08, 2001. The results are shown in Table 4.

Table 4. HAPs Y12E Sampling Results

Metal of Concern	2001 Results μg/m^3	2000 Results μg/m^3	1999 Results μg/m^3	Guideline Concentration μg/m^3
Arsenic	ND	ND	< 0.01	0.0023 [1]
Beryllium	ND	ND	< 0.001	0.004 [1]
Cadmium	ND	ND	< 0.001	0.0056 [1]
Total Chromium	< 0.001	< 0.001	0.0005	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	· 0.0045	0.0035	0.0056	1.5 [2]
Nickel	< 0.001	< 0.001	< 0.001	0.042[1]
Uranium	ND	ND	< 0.01	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

HAPs metals were monitored at station Y12W through the periods 1/1-1/4, 2/05-3/13, 5/30-8/14, 11/08-12/31 2001. The results are shown in Table 5.

Table 5. HAPs Y12W Sampling Results

Metal of Concern	2001 Results $\mu g/m^3$	2000 Results $\mu g/m^3$	1999 Results $\mu g/m^3$	Guideline Concentration $\mu g/m^3$
Arsenic	ND	ND	< 0.01	0.0023 [1]
Beryllium	ND	ND	< 0.001	0.004 [1]
Cadmium	ND	ND	< 0.001	0.0056 [1]
Total Chromium	ND	< 0.001	0.0016	0.00083[1] Cr VI 1000.0[1] Cr lll
Lead	0.0035	0.0042	0.0056	1.5 [2]
Nickel	< 0.001	< 0.001	< 0.0011	0.042[1]
Uranium	ND	ND	< 0.01	0.015[3]

[1]40 CFR Part 266 Appendices; IV, Reference Air Concentrations, V, Risk Specific Doses
[2]National Ambient Air Quality Standards (NAAQS) for Lead
[3]Derived Concentration Guide 100 mrem inhalation dose. DOE Order 5400.5

Levels of Total Chromium were compared to the Risk Specific Dose levels for Hexavalent Chromium at the following monitoring locations: Y-12E, Y-12W, X10W and X10E. As Hexavalent Chromium is a constituent of Total Chromium, it is highly unlikely that these levels of Total Chromium would translate into elevated levels of Hexavalent Chromium. These results are consistent with prior sampling efforts and demonstrate no elevation of Total Chromium in the ambient air.

Based upon the analytical data generated at these monitoring sites, it would appear that there has been no significant change in levels of any metals of concern in the ambient air on and around these sampling points at the ORR. Background levels, collected near Norris Lake were slightly lower than samples on the ORR. This would be expected when comparing an industrialized area to a more remotely located residential area.

This project has been re-authorized to continue into 2002. Sampling sites will remain as they have for the year 2001. Future D&D activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by TDEC.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2001 was not available. However, analytical results from the 2001, 2000, and 1999 HAPs monitoring program were compared with the 2000 ASER, indicating comparable levels of HAPs in the ambient air in and around the ORR.

Conclusion

As a result of the 2001 monitoring campaign conducted by TDEC at the ORR sites, analytical results indicate no apparent elevated levels of HAPs metals of concerns. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis.

It should also be noted that other incinerator facilities are in the vicinity of the ORR. The possibility exists that these operations, along with the TVA Bull Run Steam Plant facility on Edgemoor Road and the Kingston Steam Plant could have an impact on the ambient air around the ORR.

References

Draft New York State Air Guide-1, Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

Boiler and Industrial Furnace Regulations - 40 CFR Part 266 Appendix V.

Yard, C.R. 2001 *Health, Safety and Security Plan*, Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge, Tennessee

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

TDEC/DOE-O Procedure number: SOP-ES&H-004 Air Monitoring/Air Sampling.

Chapter 5 AIR QUALITY MONITORING

Environmental Radiation Ambient Monitoring System (ERAMS) Air Program (RMO)

Principal Author: James L. Dunlap

Abstract

The Environmental Protection Agency's Environmental Radiation Ambient Monitoring System (ERAMS) is designed to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources (EPA, 1988). This program provides for radiochemical analysis of air samples from five monitoring stations located on the Oak Ridge Reservation. In this effort, samples are collected twice weekly at each monitoring station by personnel from the Tennessee Department of Environment and Conservation (TDEC) to be analyzed at the EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. Results are provided to TDEC and published in a quarterly EPA report, *Environmental Radiation Data* (available on the Internet). While not all of the data for 2001 has been processed, gross beta results were similar for each ERAMS monitoring station. These results followed trends previously observed in TDEC's Perimeter and Fugitive Air Monitoring Programs. Currently available ERAMS data, along with results from associated TDEC air monitoring programs, were not indicative of a significant impact on local air quality attributable to Department of Energy activities on the reservation.

Introduction

In the past, air emissions from Department of Energy (DOE) activities on the Oak Ridge Reservation (ORR) have been believed to be a potential cause of illnesses affecting area residents. While these emissions have substantially decreased over the years with the decommissioning of various processes, concerns have remained that air emissions from current activities (e.g., incineration of radioactive wastes, production of radioisotopes, remedial activities) could pose a threat to public health and the surrounding environment. As a consequence, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division has implemented three air monitoring programs to assess the impact of ORR air emissions on the surrounding environment and the effectiveness of DOE controls and monitoring systems. TDEC's Perimeter and Fugitive Air Monitoring Programs (described in associated reports) focus on monitoring of exit pathways, non-point sources of emissions, and sites of special interest (e.g., remedial sites). TDEC's participation in the Environmental Protection Agency's (EPA) Environmental Radiation Ambient Monitoring Systems (ERAMS) supplements the other programs and provides verification of state and DOE monitoring, via independent third party analysis.

EPA's ERAMS program is comprised of a national network of monitoring stations that regularly collect samples of air, water, and milk for radiochemical analysis. Historically, this network has been used to track environmental releases of radioactivity from nuclear weapons tests and nuclear accidents. In response to TDEC requests and an initiative to incorporate site specific monitoring into the program, EPA agreed to locate five air-monitoring stations on the ORR in December of 1994. These stations began operation in 1996.

Methods and Materials

In the Oak Ridge ERAMS effort, EPA provides radiochemical analysis of air samples collected by TDEC staff at the five monitoring stations depicted in Figure 1.

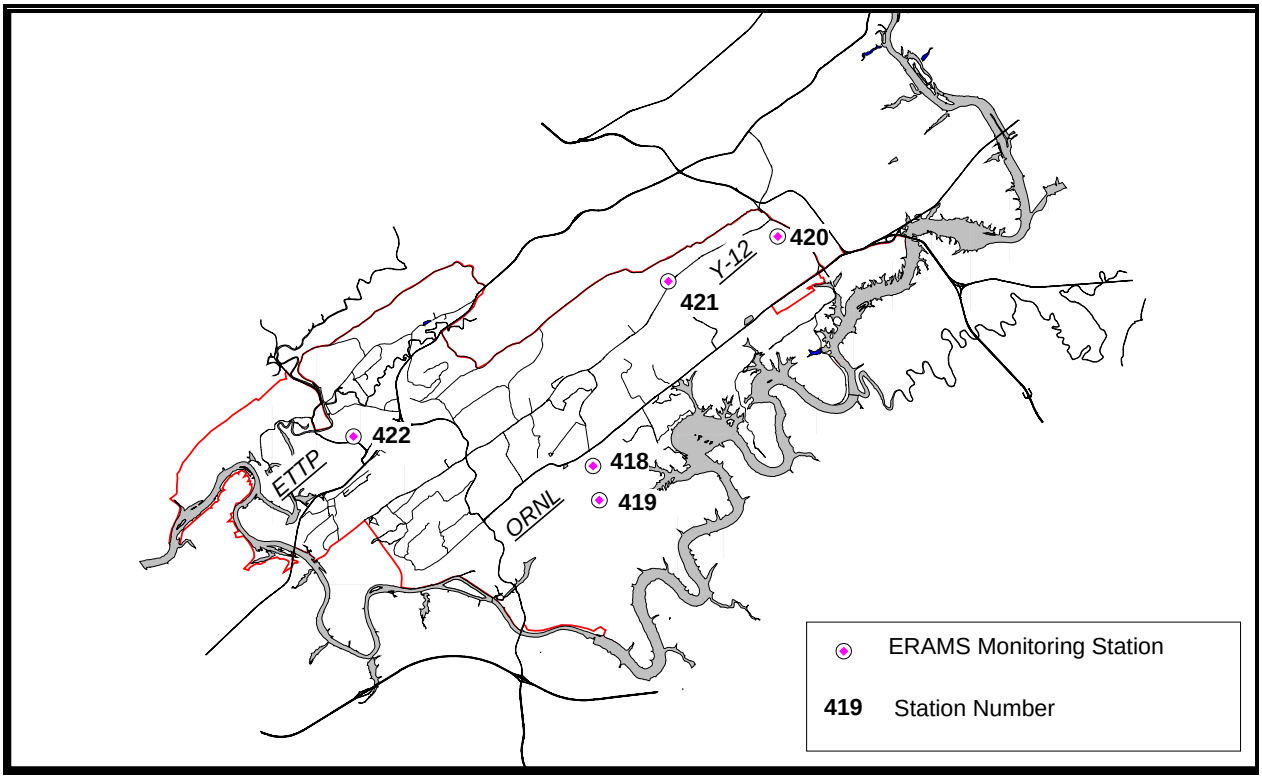


Figure 1. Approximate Locations of Air Stations Monitored in Association with EPA's Environmental Radiation Ambient Monitoring System on the Oak Ridge Reservation

The ERAMS air monitors use synthetic fiber filters, ten centimeters in diameter, to collect airborne particulates moving through the units. The monitors are operated continuously and TDEC staff change filters twice weekly. Airflow through each unit is recorded before and after the filter change. As prescribed in *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (EPA, 1988), the quantity of radioactivity on each filter is estimated by state personnel using a Geiger-Mueller radiation detector before the samples are shipped to EPA for analysis.

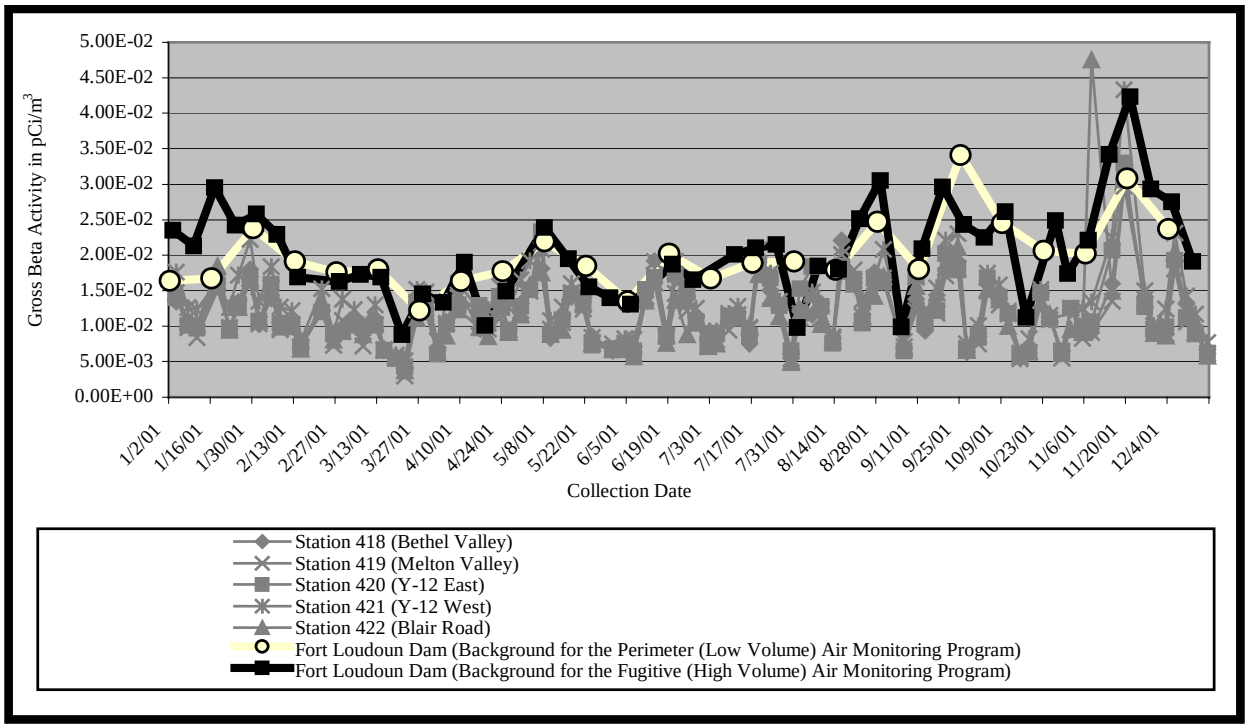
Radiochemical analysis is performed on the filters at EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama. Analytical parameters (Table 1) include: gross beta on each of the twice weekly samples; gamma spectrometry on samples that exhibit a gross beta activity greater than 1 pCi/m^3; and plutonium-238, plutonium-239, plutonium-240, uranium-234, uranium-235, and uranium-238 semiannually on composite samples. The results are provided to TDEC and published by EPA in a quarterly report titled *Environmental Radiation Data*. This publication is currently available on the internet at http://www.epa.gov/narel/erams.html.

Table 1: EPA Analysis of Air Samples Taken in Association with the Environmental Radiation Ambient Monitoring System

ANALYSIS	FREQUENCY
Gross Beta	Each of twice weekly samples
Gamma Scan	Samples showing greater than 1 pCi/m^3 of gross beta
Plutonium-238, Plutonium-239, Plutonium-240, Uranium-234, Uranium-235, Uranium-238	Semiannually on composite air particulate filters

Results and Discussion

The gross beta results for each ERAMS monitoring station followed the same general trends noted in the TDEC's Perimeter and Fugitive Air Monitoring Programs. Figure 2 illustrates the correlation between the trends noted in the ERAMS results for 2001 and those observed in background samples taken at Fort Loudoun Dam in Loudon County by the low-volume air monitor used in the Perimeter Air Program and the high-volume air monitor used in the Fugitive Air Program. A prominent peak (4.75E-2 pCi/m^3) can be noted in Figure 2 on 11/08/01 for the Blair Road Station (422). This result is in the range of background values, but considerably higher than the results reported for the other stations on that particular date. The cause of this anomalous data point is currently unknown.

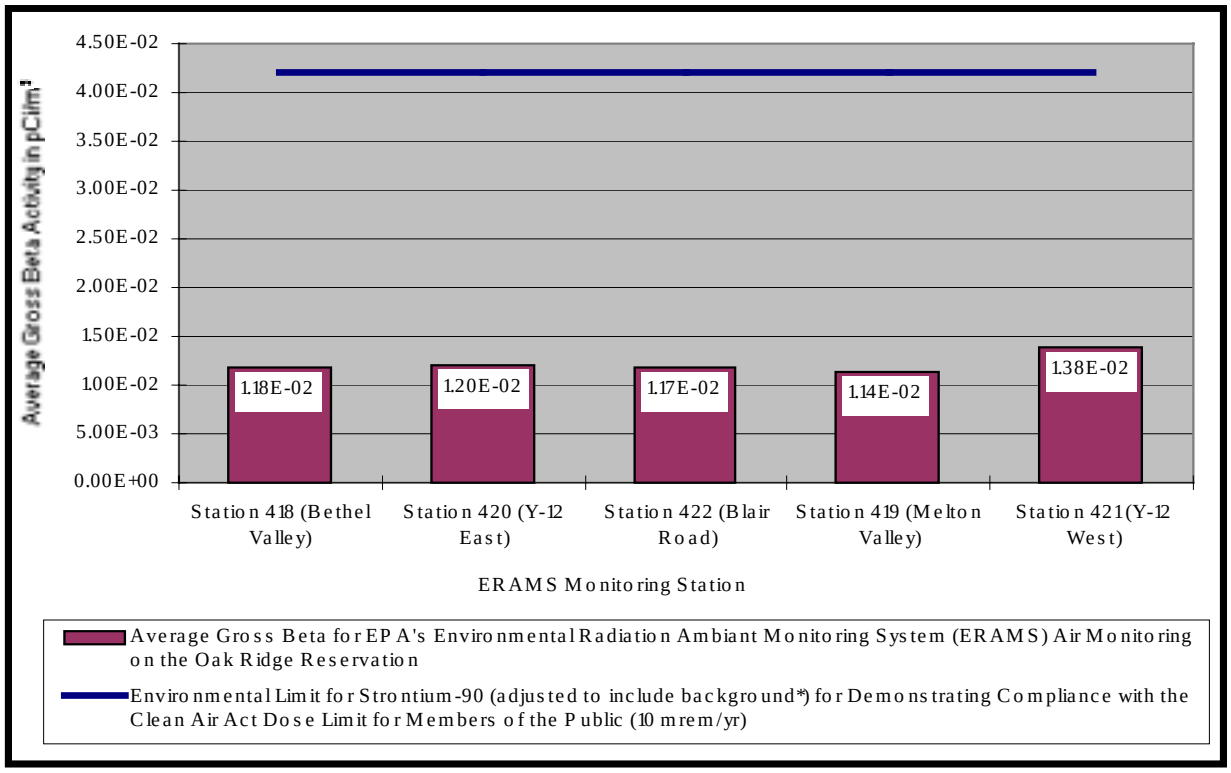


Note: Typical background values for gross beta range from 0.005 - 0.1 pCi/m^3 (ORISE, 1993)

Figure 2. Comparison of Trends in Year 2001 Gross Beta Results from Air Samples taken on the Oak Ridge Reservation in Association with EPA's Environmental Radiation Ambient Monitoring System and Background Data collected in TDEC's Perimeter and Fugitive Air Monitoring Program*

* This chart is intended to illustrate the similarity in trends noted in the gross beta activity for samples associated with the ERAMS program and the Division's Perimeter Air Monitoring Program (not convey specific results).

The 2001 average gross beta results for the stations in the ERAMS program were all relatively close (0.0114 to 0.0138 pCi/m^3), given the fluctuations noted above. As in the past, the results were also consistently lower than those calculated for TDEC's Perimeter and Fugitive Air Monitoring Programs. This bias is believed to be an artifact of the different types of sample collection systems (e.g., filters, pumps, etc.) used by the programs. Figure 3 provides the 2001, average results for each station monitored under the ERAMS Program. The environmental level for strontium-90 used to demonstrate compliance with the Clean Air Act radiation dose limit for members of the public (10 mrem/yr) is provided for comparison. This level applies to the dose above background; therefore, the standard provided in the figure has been adjusted to include the average gross beta background measurement for TDEC's Perimeter Air Monitoring Program.



*The standards provide by the Clean Air Act apply to the dose above background; therefore, the standard provided for reference in this figure has been adjusted to include the background measurements taken from the division's Perimeter Monitoring Program during the same period

Figure 3: Year 2001 Average Results for Gross Beta Analysis of Air Samples taken on the Oak Ridge Reservation in Association with EPA's Environmental Radiation Ambient Monitoring System

None of the gross beta results reported by NAREL exceeded the screening level of 1 pCi/m^3 that would have required analysis by gamma spectrometry under ERAMS protocol. The results of isotopic analysis performed semiannually by NAREL on composite samples had not been completed at the time of this report.

Conclusion

The gross beta results for each of the five ERAMS air monitoring stations followed the same general trends observed in TDEC's Perimeter and Fugitive Air Monitoring Programs. Data

currently available for these programs has not been indicative of a significant impact to local air quality attributable to DOE operations on the ORR.

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Chapter 5 AIR QUALITY MONITORING

Fugitive Radiological Air Emissions Monitoring (RMO)

Principal Author: Gary Riner

Abstract

The Tennessee Department of Environment and Conservation uses a portable high volume air sampler to monitor fugitive radiological air emission at sites of interest on the Oak Ridge Reservation. A second high volume monitor has been placed at Fort Loudoun Dam in Loudon County to provide background data for comparison. During 2001, the portable unit was stationed near the K-33 Process Building at the East Tennessee Technology Park. This facility is currently undergoing cleanup activities in association with the Department of Energy's reindustrialization effort on the reservation. For the year 2001, results obtained from the K-33 site were consistently higher than measurements obtained from the background station, but well below standards provided by the Clean Air Act.

Introduction

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division conducts monitoring for fugitive radiological air emissions on and in the vicinity of the Oak Ridge Reservation (ORR). This program uses a portable high volume air monitor to supplement air sampling performed at fixed locations. In addition to its mobility, the high volume monitor provides greater measurement sensitivity and resolution than can be achieved with the low volume monitors used in the division's Perimeter Air Monitoring Program. In 2001, the portable sampler was used to monitor emissions from the K-33 Process Building at the East Tennessee Technology Park (ETTP).

Methods and Materials

Two high volume air samplers are used in this program. One of these units is mobile, allowing it to be moved to different areas of interest. The second unit has been stationed at Fort Loudoun Dam in Loudon County to collect background information. Both samplers use 8x10 glass fiber filters to collect suspended particulate matter as air is pulled through the units. The filters are collected weekly by staff and shipped by certified mail to the state's radiochemical laboratory in Nashville, Tennessee, for analysis. Analysis includes gross alpha, gross beta, and gamma spectrometry on each of the weekly samples. Additional analysis is performed where merited.

Monitoring in this program is directed toward locations where there is a potential for the release of fugitive/diffuse air emissions as a consequence of remedial or waste management activities. Results from the portable sampler are compared to background data collected by the high volume monitor placed at Fort Loudoun Dam. Results are also compared to environmental standards used to demonstrate compliance with the Clean Air Act (CAA). Last year (2001), the portable monitor was stationed near the exhaust stacks from the K-33 Process Building at ETTP. This facility was contaminated during process operations. It is currently being cleaned-up in association with DOE's reindustrialization effort.

Results and Discussion

In 2001, data from samples taken at the K-33 Process Facility followed the same trends as observed at the background station (Figures 1 and 2). The levels measured at K-33 were also consistently higher than those reported for the background station from mid February to November of 2001. While the exact cause of the slightly elevated values is not clear, they could be a consequence of releases from the K-33 facility, materials suspended during an aggressive building demolition program at ETTP in 2001, and /or localized phenomena. In any case, the values are not indicative of contaminant levels in excess of standards provided by the CAA.

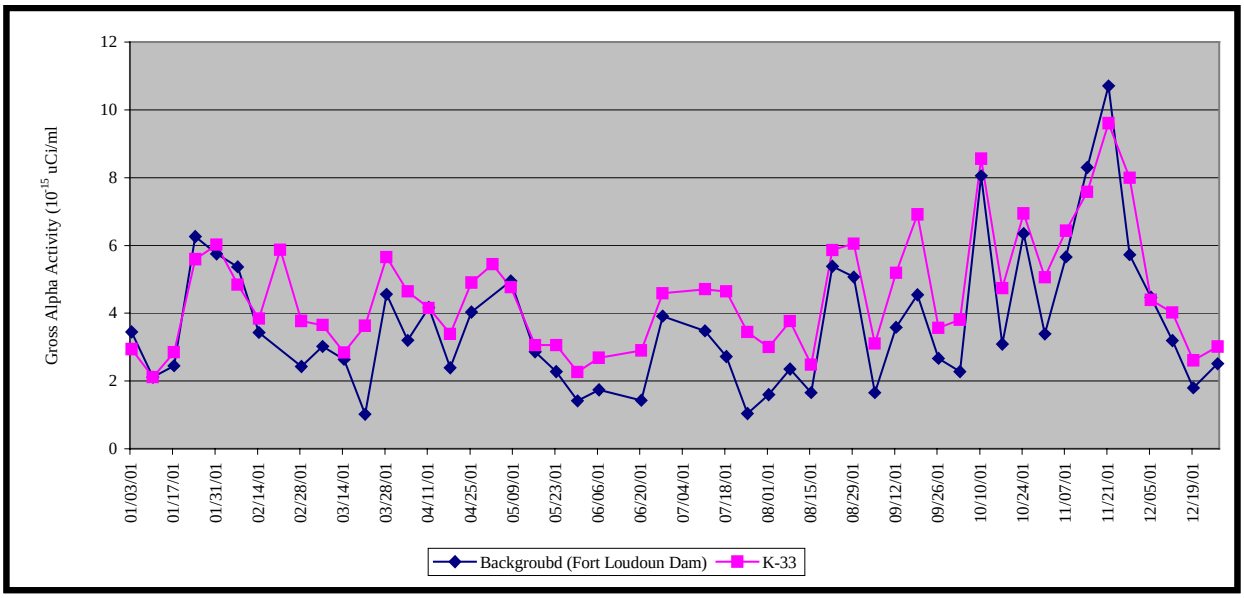


Figure 1: Gross Alpha Activities reported for Year 2001 Monitoring performed at the K-33 Process Building and the Background Station at Fort Loudoun Dam

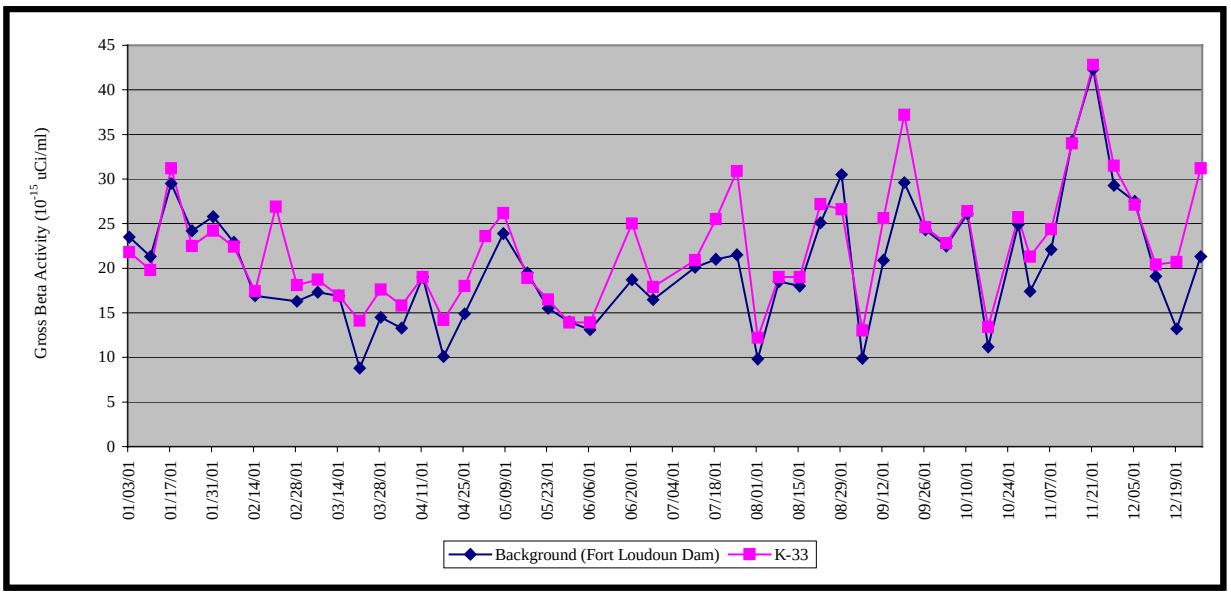
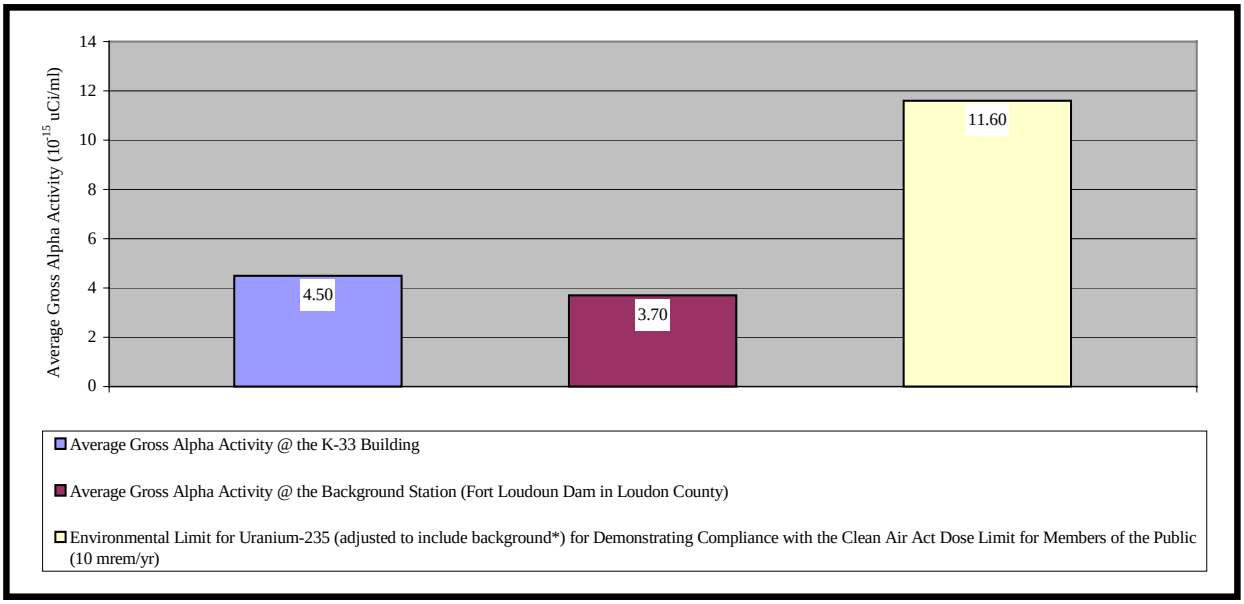


Figure 2: Gross Beta Activities reported for Year 2001 Monitoring performed at the K-33 Process Building and the Background Station at Fort Loudoun Dam

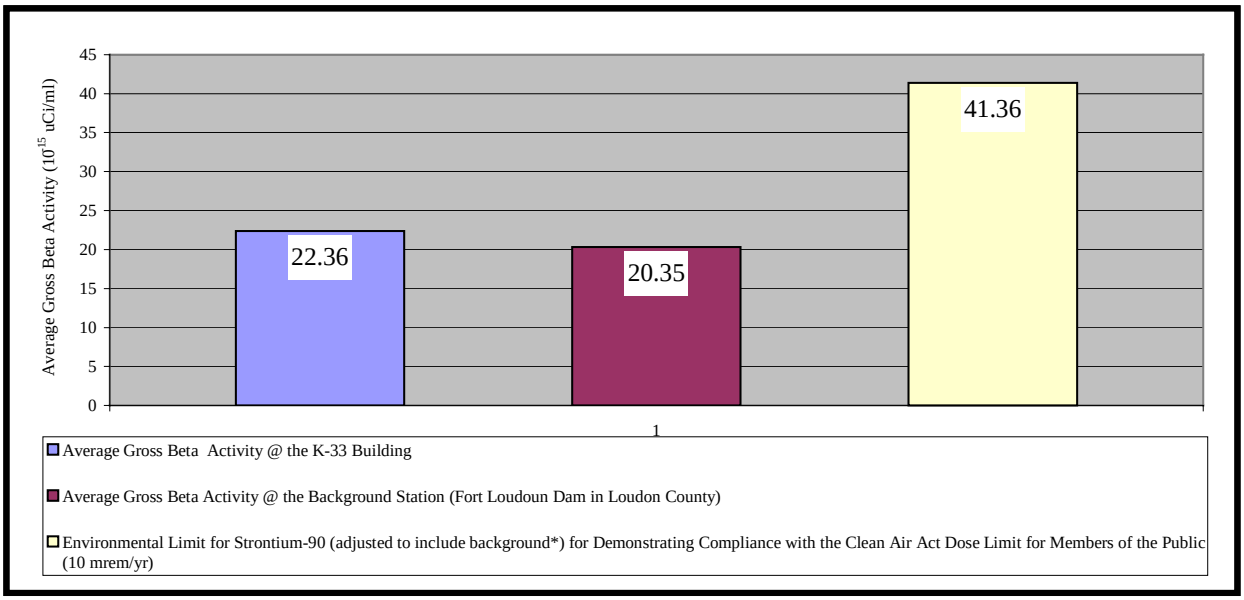
The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year. Compliance with this standard is generally determined for point source emissions that employ air dispersion models to predict the dose at off-site locations. However, the CAA also provides environmental concentrations for radionuclides that can be used to demonstrate compliance with the 10 mrem/yr limit. TDEC staff use these standards to evaluate the predictions derived from air dispersion models and assess fugitive emissions. Because to the hazards associated with the various radionuclides differ significantly, the CAA requires specific analysis for each isotope determined to be of concern. Consequently, the standards provided by the CAA do not include limits for gross alpha and beta activities. Nevertheless, the more economical gross measurements, when treated as surrogates for the more hazardous isotopes, can provide an effective screening mechanism to determine if further evaluation is warranted. To this end, staff compare the gross measurements obtained in TDEC's air sampling programs to some of the more restrictive standards provided by the CAA.

The average gross alpha and beta activities for TDEC's fugitive air monitoring at the K-33 Building and the Fort Loudoun background station are provided in Figures 3 and 4. The CAA standards provided for reference are those of uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter). Since the environmental standards provided by the CAA apply to the dose above background, the standards provided for reference in these figures have been adjusted to include the background measurement.



*The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include the background measurements taken from the Division's perimeter monitoring program during the same period.

Figure 3: Average Gross Alpha measured at the K-33 Process Building during 2001 compared to Background Measurements and the Concentration Level for Uranium-235 to Demonstrate Compliance with the Clean Air Act Dose Limit for Members of the Public



*The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include the background measurements taken from the Division's perimeter monitoring program during the same period.

Figure 4: Average Gross Beta Measured at the K-33 Process Building during 2001 compared to Background Measurements and the Concentration Level for Strontium-90 to Demonstrate Compliance with the Clean Air Act Dose Limit for Members of the Public

Conclusion

During 2001, measurements of fugitive emissions taken near the K-33 Process Building by TDEC were not indicative of airborne radionuclides (attributable to DOE activities) at levels above CAA standards.

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Chapter 5 AIR QUALITY MONITORING

Oak Ridge Reservation Perimeter Ambient Air Monitoring Program (RMO)

Principal Author: James L. Dunlap

Abstract

The Tennessee Department of Environment and Conservation conducts a perimeter air monitoring program on the Oak Ridge Reservation using low volume air samplers. This program, in conjunction with associated air monitoring programs, provides information used to assess the impact of Department of Energy activities on the local environment and public health. In the program, samples are collected biweekly from twelve air monitors stationed near the boundaries of the reservation and at a background location (i.e., Fort Loudoun Dam). Each of the samples is analyzed for gross alpha and gross beta radiation at the state radiochemistry laboratory. A composite sample from each location is analyzed annually for gamma emitters. Results from the perimeter monitoring stations are compared to the background measurements and environmental standards provided in the Clean Air Act. In 2001, data from the program did not indicate a significant impact on local air quality from activities on the reservation.

Introduction

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division provides radiochemical analysis of air samples taken from twelve low volume air monitors located on and in the vicinity of the Oak Ridge Reservation (ORR). The monitors used to collect the samples are owned by DOE and maintained by DOE contractors. Data derived from this program, along with information generated by the other air monitoring programs on the reservation, is used to (1) assess the impact of DOE activities on the public health and environment, (2) identify and characterize unplanned releases, (3) establish trends in air quality, and (4) verify data generated by DOE and its contractors.

Methods and Materials

The twelve air monitors used in the program are owned by DOE and DOE contractors are responsible for their maintenance and calibration. Nine of the units are a component of DOE's ORR perimeter air monitoring system. The remaining three monitors were previously used by the Y-12 facility in their perimeter air monitoring program. All the monitors use forty-seven millimeter borosilicate glass fiber filters to collect particulates as air is pulled through the units. The ORR perimeter monitors employ a pump and flow controller to maintain airflow through the filters at approximately two standard cubic feet per minute. The Y-12 monitors use a pump and rotormeter which indicates an average flow rate of approximately two cubic feet per minute.

Air filters are collected from the monitors biweekly and sent by certified mail to the state's radiochemical laboratory in Nashville, Tennessee, for analysis. Analysis includes gross alpha and gross beta on the biweekly samples. Gamma spectrometry is performed on any samples that exhibit elevated gross results and annually on composite samples.

The twelve air monitoring stations used in the program are listed in Table 1. Eleven of these stations are located around the perimeter of the ORR and Y-12 facility. The twelfth site is a background station located at Fort Loudoun Dam in Loudon County. (Figure 1)

Table 1: Perimeter Air Monitoring Stations

Station	Location	County
4	Y-12 Perimeter near portal 2	Anderson
5	Y-12 Perimeter near Building 9212	Anderson
8	Y-12 Perimeter west end near portal 17	Anderson
35	East Tennessee Technology Park	Roane
37	Bear Creek at Y-12 / Pine Ridge	Roane
38	Westwood Community	Roane
39	Cesium Fields at Oak Ridge National Laboratory	Roane
40	Y-12 East	Anderson
42	East Tennessee Technology Park off Blair Road	Roane
46	Scarboro Community	Anderson
48	Deer Check Station on Bethel Valley Road	Anderson
52	Fort Loudoun Dam (Background Station)	Loudon

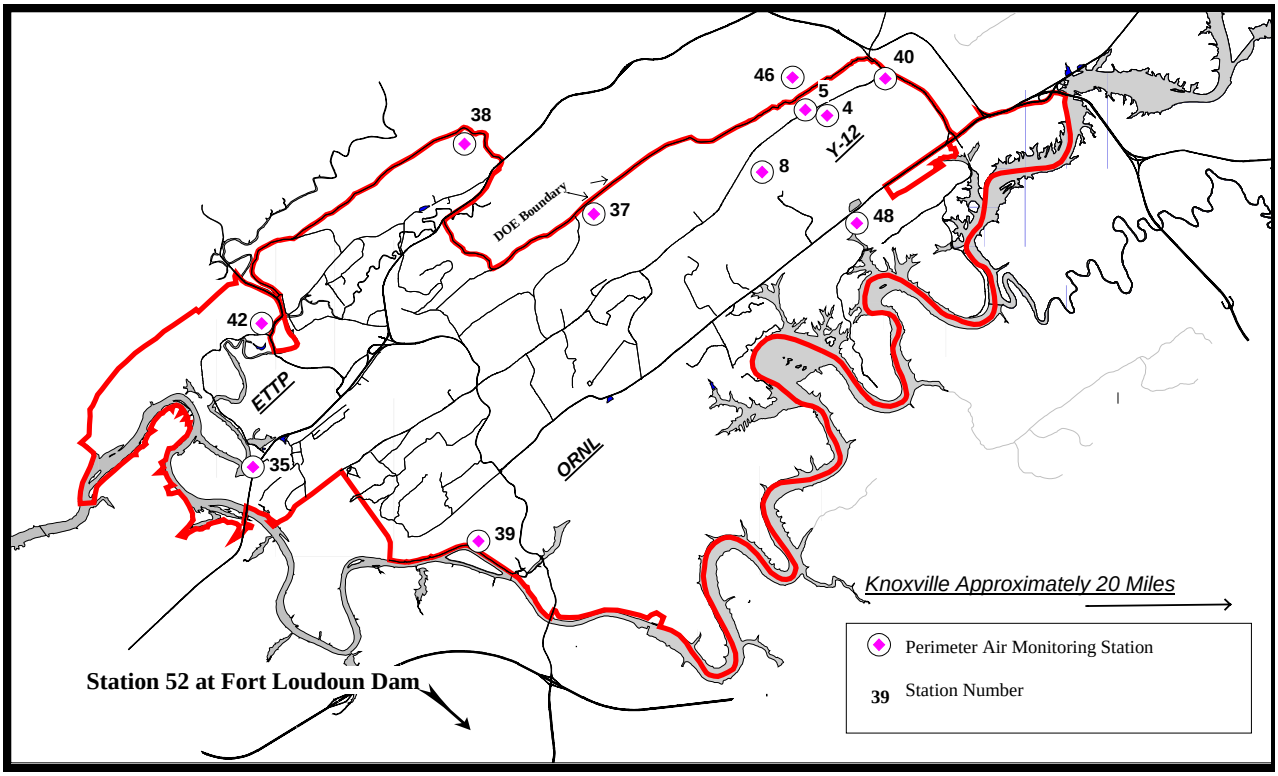


Figure 1: Approximate Location of Perimeter Air Monitoring Stations

Results and Discussion

In 2001, results reported for the perimeter air monitoring stations were near those reported for the background station. Similar trends in the activities for gross alpha and gross beta were observed for each monitoring station. Figures 2 and 3 illustrate the correlation between fluctuations in the gross alpha and beta results at the perimeter stations and the background location. These fluctuations, to a large degree, can be attributed to natural phenomena or changing environmental conditions, which increase or decrease the amount of particulate deposited on the sampling filters. For example, concentrations of potassium-40 and radionuclides in the uranium and thorium decay series may increase, because soils in which they naturally occur have been dispersed in the air as a consequence of dry conditions, heavy winds, and/or local activities (e.g., construction). Conversely, rain and snow can remove materials suspended in the air reducing the concentration of contaminants deposited on the air filters. Concentrations of cosmogenic radionuclides (e.g., beryllium-7) are also highly variable, fluctuating in response to sunspot activity and the degree of mixing between the stratosphere, where they are produced, and the troposphere, where TDEC samples (ORISE, 1993).

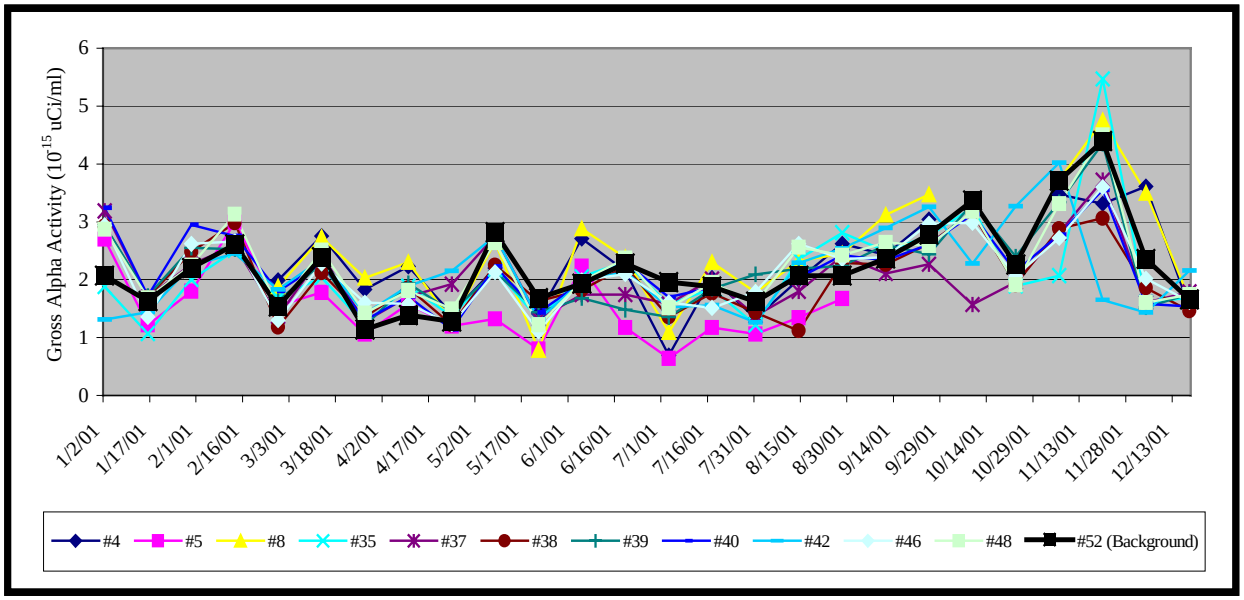


Figure 2: Gross Alpha Results from Perimeter Air Monitoring for the Year 2001

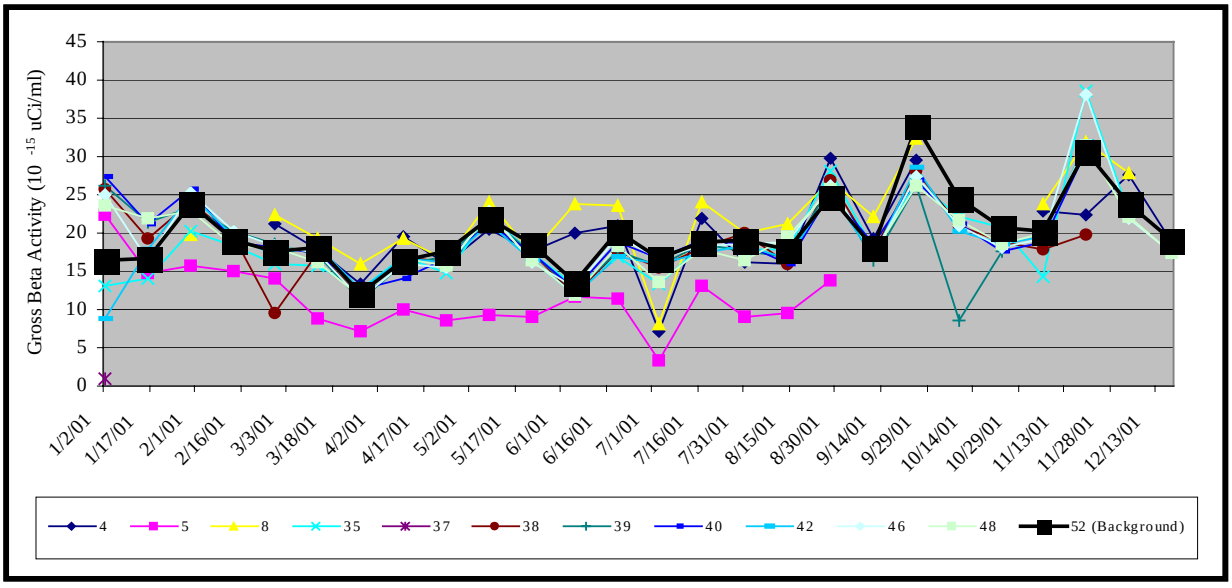


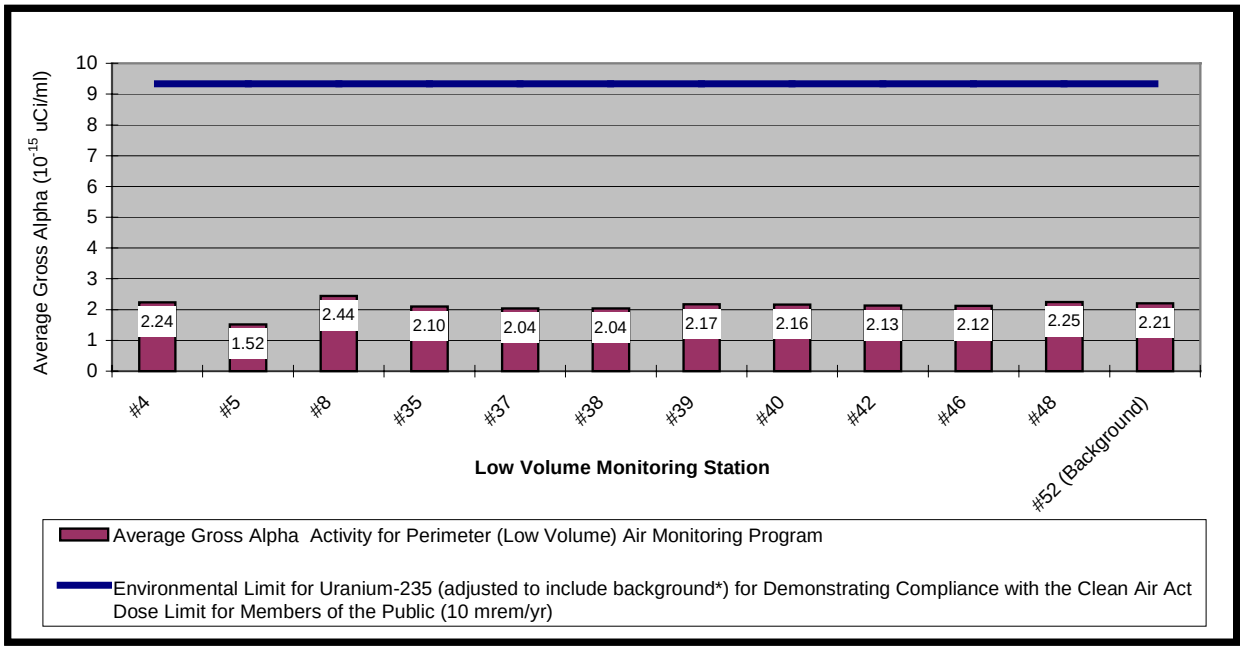
Figure 3: Gross Beta Results from Perimeter Air Monitoring for the Year 2001

The simplest method of assessing the impact of ORR air emissions on the local environment is to compare results from the perimeter monitoring stations to those of the background station located at Fort Loudoun Dam (Station 52). As can be seen in Figures 2 through 5, the activities reported for the perimeter air stations for gross alpha and gross beta were relatively consistent with the background values. It can also be noted in the figures, the concentrations reported for station number 5 were lower than those reported for the other monitoring locations. This station is one of three in the program (stations 4, 5, and 8) previously used in Y-12's air monitoring program. The efficiency of the samplers associated with these stations came into question after staff noted results for these locations were consistently lower than data from the other monitoring stations. The installation of new vacuum pumps in the samplers at stations 4 and 8 resulted in

data more consistent with results from the other air stations. Results for station 5, which was not upgraded, continued to be lower than those reported for the remaining stations. Monitoring at station 5 was indefinitely suspended after September 11, 2001, due to heightened security precautions at Y-12.

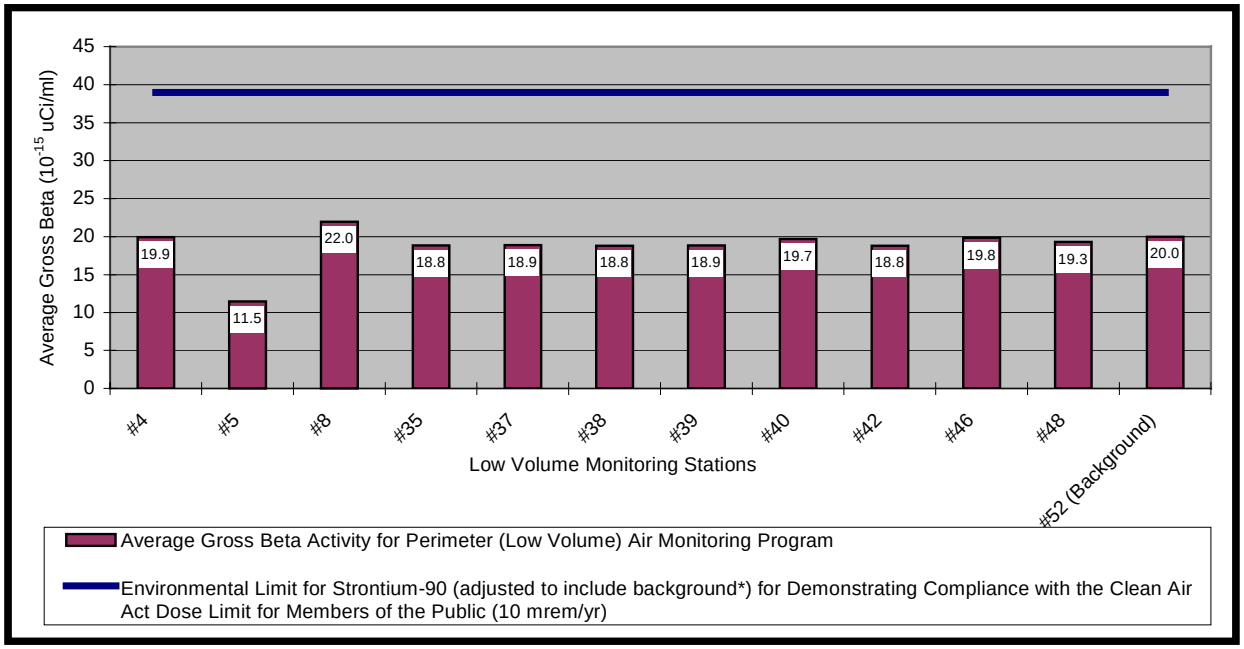
The Clean Air Act (CAA) specifies that exposures to the public from radioactive materials released to the atmosphere from DOE facilities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem. Data from TDEC's air monitoring is compared to ambient air concentrations provided in the CAA for demonstrating compliance with the 10 mrem/yr limit. While the CAA environmental standards do not include limits for gross alpha and beta, these measurements provide an effective tool to assess if further investigation merited.

Figures 4 and 5 show the average activity for gross alpha and beta measured during the year 2001 at the perimeter air stations. The CAA environmental standards (adjusted to include background radiation) for uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter) provides for comparison. These isotopes have some of the more restrictive standards prescribed by the CAA. It should be understood that it is very unlikely that these isotopes would be responsible for a major proportion of the gross activity reported for the samples.



*The standards provide by the Clean Air Act applies to the dose above background: therefore, the standard provided for reference in the figure has been adjusted to include the background measurements.

Figure 4: Average Gross Alpha Results for Perimeter Air Monitoring for the Year 2001



*The standards provide by the Clean Air Act applies to the dose above background: therefore, the standards provided for reference in the figure has been adjusted to include the background measurement.

Figure 5: Average Gross Beta Results for Perimeter Air Monitoring for the Year 2001

The annual gamma analysis performed on composite samples from each station has not been completed; consequently, these results were not available for this report. In the past, the gamma results have been considered consistent with background measurements.

Conclusion

Environmental concentrations of radionuclides in the atmosphere tend to vary from location to location and seasonally in response to natural and anthropogenic influences. In this regard, results of radiochemical analysis of samples taken at ORR perimeter air monitoring stations appear to follow similar trends as the background station located near Fort Loudoun Dam. Concentrations of radionuclides reported for the perimeter air monitoring stations, also, seem consistent with data reported for the background stations, given the natural variability associated with concentrations of radionuclides in the environment.

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Chapter 6 GROUNDWATER MONITORING

Residential Well Sampling Program Project Report

Principal Author: Robert C. Benfield

Abstract

During the calendar year 2001, the Tennessee Department of Environment and Conservation Department of Energy Oversight Division conducted a routine program of sampling residential wells. The purpose of the project is to identify groundwater users in areas off of the Oak Ridge Reservation (ORR) that might use groundwater impacted by DOE activities. To achieve this a well user survey was conducted by going house to house and determining the location of families using well water for consumption and bathing. Wells to be sampled were selected using geology, geographic location and depth of well. Sampling was performed throughout the year.

Analysis of the results showed no discernible impact from the activities of DOE on the ORR. The general groundwater quality of the 8 residential wells appears to be good. Most homeowners interviewed during the 1996 house-to-house survey indicated no problem with groundwater quality. The analytical results from sampling these wells indicated that groundwater quality in these wells is adequate for drinking and household uses.

Introduction

In 1996 the Tennessee Department of Environment and Conservation DOE Oversight Division (TDEC/DOE-O) initiated a residential well sampling program. The purpose of this project was to identify areas of groundwater use for consumption and bathing in the areas off site from the Oak Ridge Reservation (ORR) and determine the environmental impact on groundwater in these areas from past ORR operations. Two major tasks were included in this project: identify residences with drinking water wells and collect groundwater samples for analysis from selected wells. In 1996 and 1997 a house-to-house survey was conducted.

The user survey was conducted in the area southwest and within two miles of the ORR boundary. This survey was concentrated in areas in line and along geologic strike with the DOE X-10 and Y-12 facilities. A total of 71 residential wells have been identified. A well survey form was completed for each well. It should be noted that the ORR is over 28,000 acres and the city of Oak Ridge and Knox County supplies water for a large area north and southeast of the ORR. Typical distances from residential wells to active DOE facilities are two miles.

During 2001, TDEC/DOE-O collected water samples from 8 residential wells. Most of these wells were identified during the house-to-house survey. These residential wells are separate from and in addition to TDEC DOE-O sampling on and off-site exit pathway springs and wells that are or might be impacted by DOE activities. Figure 1 shows the location of these wells. Two of the wells were added as a result of a notice that was released to the news media in 1999 concerning well sampling. Each of these wells was sampled and then analyzed for chemical and radiological analytes.

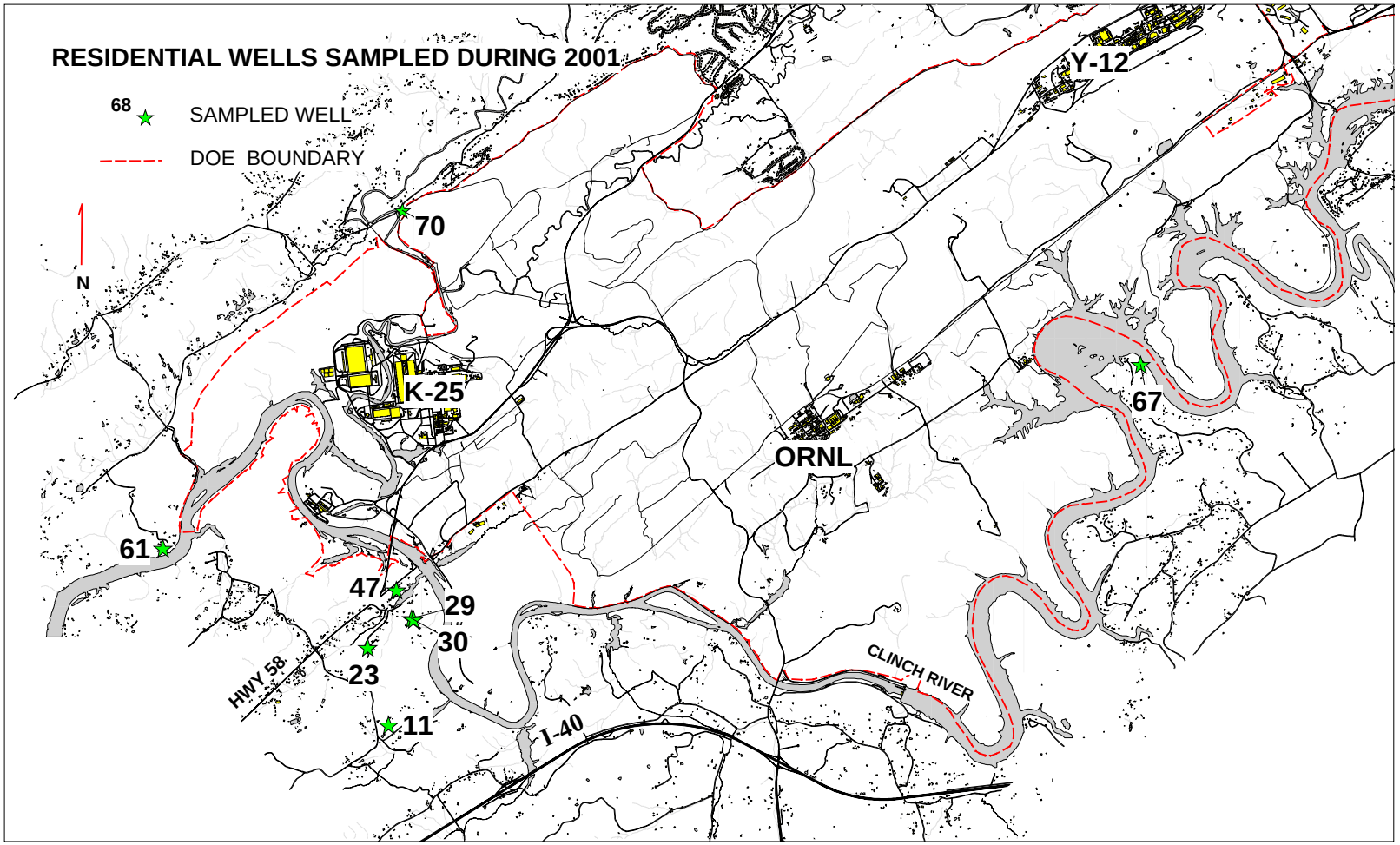

Figure 1. Residential Wells Sampled in 2001

Methods and Materials

A work plan was prepared for standardizing the collection of groundwater samples from residential wells identified during the house-to-house survey. The locations of the 71 wells identified during this survey were reviewed. From this review, 8 residential wells were selected to be sampled. These wells were located generally along a line or transect normal to geologic strike in the area across the Clinch River and southwest of the X-10 and Y-12 facilities. Other wells were selected to test for the effects of DOE across Melton Hill Lake and north of the ORR. See Figure 1 for the location of the 8 wells. These wells were selected along this transect to possibly locate contaminants migrating off site from the ORR via groundwater.

The well samples were analyzed for volatile organic compounds (VOCs), nutrients, radiochemistry, general inorganics, and selected metals. These analytes were selected to identify general groundwater quality in these wells and identify chemical and radiological substances used in past ORR operations. The results were compared to established regulatory maximum contaminant levels (MCLs).

The residential wells were generally sampled from a water tap located outside the property owner's house. Prior to sampling, water was run until pH, temperature and conductivity readings stabilized. The water quality parameters were constantly checked using portable meters. Water was normally run from the tap for at least 10 minutes before these parameters were stabilized. Water samples were taken immediately after these parameters stabilized.

Samples were collected in laboratory prepared bottles using clean surgeon's gloves. Immediately after sample collection, water samples were placed on ice in a cooler. The time of sample collection and other pertinent information was recorded in a field logbook on site. Chain of custody forms were filled out from this information. Sample tags were completed and placed on the sample containers immediately after each sample was collected. Water samples were delivered to the state of Tennessee analytical laboratory in Knoxville, Tennessee for analysis.

TDEC/DOE-O sent the analytical results to the owner of each sampled residential well. The analytical results from each well were entered into a computer database, and a cover letter was drafted to be included with the analytical results.

Results and Discussion

The analytical results from sampling the 8 residential wells were compared with regulatory MCLs. These results see Table 1, indicate that water samples taken from these wells did not exceed these regulatory limits.

The metal analysis results compared to MCLs are found below in Figure 2.

Conclusion

The general groundwater quality of the 11 residential wells appears to be good. Most homeowners interviewed during the 1996 house-to-house survey indicated no problem with groundwater quality. Well users contacted by the division since the survey have also indicated no concerns about their water quality. The analytical results from sampling these wells indicated that groundwater quality in these wells is adequate for drinking, bathing and household uses.

All data indicate that the sampling results are in a range that could be considered background water quality. The metals that show up are below MCLs but somewhat higher than springs in and around the reservation. The higher metals are most likely due to pumps, wiring and metal plumbing or well casing. The radiological data is normal for water in the ORR area, essentially background. The spurious volatile organic compound is most likely a lab contaminant or sampling artifact. Sampling of the residential sources of water will continue under this project.

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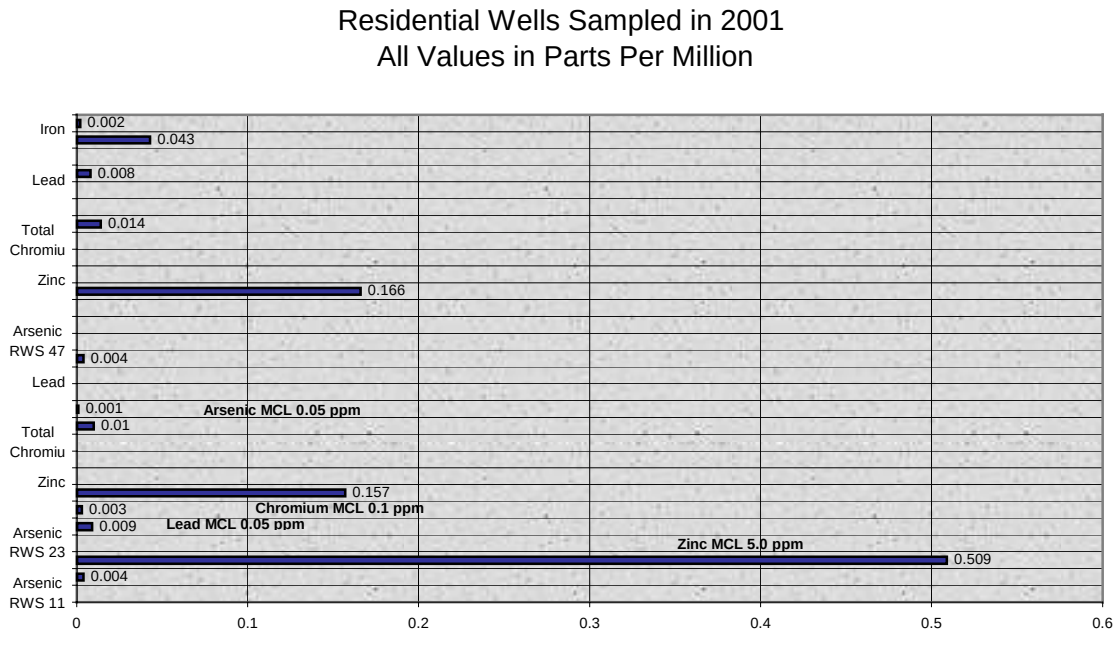

Figure 1 Select metals for residential water sources sampled in 2001, all below the Maximum

Table 1. Detected Analytes at Locations Sampled in Calendar Year 2001

8 Residential Wells			Results ppm or pCi/L		Rad Error +-	
Location Name	Analysis	PARAMETER	Spring	Fall	Spring	Fall
RWS 11	Inorganic	Arsenic	0			
		Cadmium	0			
		Lead	0.004			
		Mercury	0			
		Selenium	0			
		Thallium	0			
		Uranium	0			
		Zinc	0.509			
	Radiological	Gross Alpha	-0.1		2.6	
		Gross Beta	-0.1		2.1	
		Tritium	66		102	
	Organic	Volatiles Not Detected	0			
RWS 23	Inorganic	Arsenic	0			
		Cadmium	0			
		Lead	0.009			
		Mercury	0			
		Selenium	0			
		Thallium	0			
		Total Chromium	0.003			
		Uranium	0			
		Zinc	0.157			
	Radiological	Bi-214	13		3.3	
		Gross Alpha	2.3		2.4	
		Gross Beta	2.6		2.3	
		Tritium	94		103	
	Organic	Volatiles Not Detected	0			
RWS 29	Inorganic	Arsenic	0			
		Cadmium	0			
		Lead	0			
		Mercury	0			
		Selenium	0			
		Thallium	0			
		Total Chromium	0			
		Uranium	0			
		Zinc	0.01			
	Radiological	Bi-214	58.9		5.1	
		Gross Alpha	-0.3		2.4	
		Gross Beta	2.3		2.2	
		Pb-214	40.6		6.8	
		Tritium	45			
	Organic	Volatiles Not Detected	0			
RWS 30	Inorganic	Arsenic	0.001			
		Cadmium	0			

8 Residential Wells			Results ppm or pCi/L		Rad Error +-	
Location Name	Analysis	PARAMETER	Spring	Fall	Spring	Fall
		Lead	0			
		Mercury	0			
		Selenium	0			
		Thallium	0			
		Total Chromium	0			
		Uranium	0			
		Zinc	0.004			
	Radiological	Bi-214	179		7.9	
		Gross Alpha	1.5		3.2	
		Gross Beta	1		2.3	
		Pb-214	191.6		7.8	
		Tritium	39		102	
	Organic	Volatiles Not Detected	0			
RWS 47	Inorganic	Arsenic	0			
		Cadmium	0			
		Lead	0			
		Mercury	0			
		Selenium	0			
		Thallium	0			
		Total Chromium	0			
		Uranium	0			
		Zinc	0.166			
	Radiological	Bi-214	174.1		8	
		Gross Alpha	-1.2		1.9	
		Gross Beta	1.2		2.3	
		Pb-214	201.1		8.2	
		Tritium	147			
	Organic	Volatiles Not Detected	0			
RWS 61	Inorganic	Arsenic	0			
		Cadmium	0			
		Lead	0			
		Mercury	0			
		Selenium	0			
		Thallium	0			
		Total Chromium	0			
		Uranium	0			
		Zinc	0.014			
	Radiological	Bi-214	66		5.3	
		Gross Alpha	0.7		2.2	
		Gross Beta	2.1		2.2	
		Pb-214	67.7		5.5	
		Tritium	90		103	
	Organic	Bromodichloromethane	0.0011			
		Chloroform	0.0025			
RWS 67	Inorganic	Arsenic	0			

8 Residential Wells			Results ppm or pCi/L		Rad Error +-	
Location Name	Analysis	PARAMETER	Spring	Fall	Spring	Fall
		Cadmium	0			
		Lead	0			
		Mercury	0			
		Selenium	0			
		Thallium	0			
		Uranium	0			
		Zinc	0.008			
	Radiological	Bi-214	112.3		6.5	
		Gross Alpha	1		3.2	
		Gross Beta	0.7		2.2	
		Pb-214	97		7.5	
		Tritium	19		102	
	Organic	Volatiles Not Detected	0			
RWS 70	Inorganic	Arsenic		0		
		Iron		0.043		
		Lead		0.002		
		Mercury		0		
		Uranium		0		
	Radiological	Bi-214		18.8		3.7
		Gross Alpha		2		5.4
		Gross Beta		3.9		2.3
		Pb-214		16.3		3.7
RWS 70 Dup.		Gross Alpha		-1.7		5
		Gross Beta		2.4		2.2

Chapter 6 GROUNDWATER MONITORING

Oak Ridge Reservation and Vicinity Spring and Seep Monitoring Project Report

Principal Author: Robert C. Benfield

Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (TDEC/DOE-O) conducts independent sampling of springs and seeps on the Oak Ridge Reservation (ORR) as part of the Tennessee Oversight Agreement (TOA). This sampling has been ongoing since 1992. This report provides a status review of the sampling performed during calendar year 2001. Samples were taken at different times of the year all over the Oak Ridge reservation. Springs and seeps act as opportune exit pathway monitoring points. Some of these points are close to burial grounds and others are some distance away. The Division is always looking for springs and seeps that act as inexpensive monitoring opportunities.

The sampling for 2001 provided some insights into the behavior of contaminants in the subsurface and their movement in the groundwater. Springs in Bear Creek Valley down gradient from the Bear Creek Burial Grounds continue to be impacted by radiochemical, metal as well as volatile organic constituents. Several springs at K-25, Y-12 and X-10 are impacted as well. Volatile Organics, Nitrates, Gross Alpha and Gross Beta activity are the contaminants of greatest concern. The levels of the contaminants with some exceptions near waste sites are very low and the general quality of the groundwater on the ORR is good.

Introduction

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (TDEC/DOE-O) conducts independent sampling of springs and seeps on the Oak Ridge Reservation (ORR) as part of the Tennessee Oversight Agreement (TOA). The state laboratory tests the samples for radionuclides, volatile organic compounds, selected metals, nutrients, and inorganic analytes (Table 1). During 2001, DOE-O sampled 35 springs, seeps and well on the ORR (Figure 1) and tabulated the results. Several of these have been found to contain contaminants, which indicate high probability of a connection with DOE's activities on the ORR.

Methods and Materials

DOE-O's spring/seep sampling activities typically include the following:

1. Locating. Springs/seeps are normally found along the lower edge of slopes near streams, often emerging in streambeds. Reviewing a topographic map of the area of concern will allow the investigator to narrow the search area areas and to mark the map location with considerable accuracy. During 2001, DOE-O used a GPS instrument to determine latitude and longitude of most of the springs.

2. Analysis A list of analytes was selected consisting of parameters that would be consistent with constituents of groundwater found on the ORR. These parameters included radionuclides, volatile organic compounds (VOCs), and inorganic constituents, nutrients and metals.

3. Field sampling A sampling team normally consisting of two DOE-O personnel, locates the spring, and collects the prescribed number of samples. The personnel wear disposable vinyl

gloves while collecting samples. Sample labels (tags) and analysis request/chain of custody forms are completed. Samples are transported in coolers to the DOE-O offices for temporary storage, or may be taken directly to the Knoxville Branch Laboratory (KBL).

Duplicate samples, trip blanks, and field blanks are taken as directed by the sampling plan.

4. Data Storage Analytical results are stored in 3-ring binders in the DOE-O office, and the results are entered in a computer database. Eventually this data will be placed onto DOE's OREIS database. Copies of the lab analyses are periodically provided to DOE.

Results and Discussion

Groundwater sampling results in the calendar year 2001 are summarized in the tables and figures in this section. A total of 35 separate locations include springs and well generated 39 (4 duplicate) sets of data in the year 2001. The most remarkable spring found and sampled this year is the JES Sludge Seep. JES Sludge Seep is intermittent spring on Bear Creek near the construction site for the Superfund Waste Cell. This spring was the only location sampled to have positively tested vinyl chloride. A total of 24 locations sampled did not have detections of volatile organic compounds. The other locations tested for volatile organic compounds yield results similar to past testing where maximum contaminant concentrations are not exceeded, except near sources of contamination.

Listed in Table 1 below, are the locations that had no detectable volatile organic compounds. Listed in Table 2 below are the particular volatile organic compounds that had values above detection.

Results of sampling for select metals at select locations are summarized in Table 3. All results for metals are below limits established for general use groundwater. Results are consistent with past results and expected levels for each location. Note that JES Sludge seep contained arsenic at measurable levels.

The radiological results are illustrated in the Figures 3-6. Bear Creek springs continue to show elevated levels of gross alpha that is consistent with past sampling for Y-12. Results for radiological parameters show higher values near sources of contamination and then drop off to background at most other sample locations. Tritium values (about 500pCi/L) at Crooked Tree Spring are similar to past sampling at this location near X-10. The tritium value of 600 pCi/L for SNS 1 spring is elevated compared to other locations, however the duplicate sample at 125 pCi/L is consistent with all the other locations. JES Sludge Seep (Figure 2) has the highest gross alpha most likely due to uranium from Y-12 waste disposal.

Conclusions

Certain ORR springs/seeps monitored during 2001 show traces of contaminants, which indicate an impact from past activities on the ORR. The location of the impacted springs relative to waste burial grounds suggests that the preferential direction of groundwater movement is generally along geologic strike (northeast/southwest). DOE-O plans to continue monitoring many of these springs/seeps. The new spring JES Sludge Seep will be sampled when flowing. Attached is an appendix of all the results for spring and well sampling during calendar year 2001.

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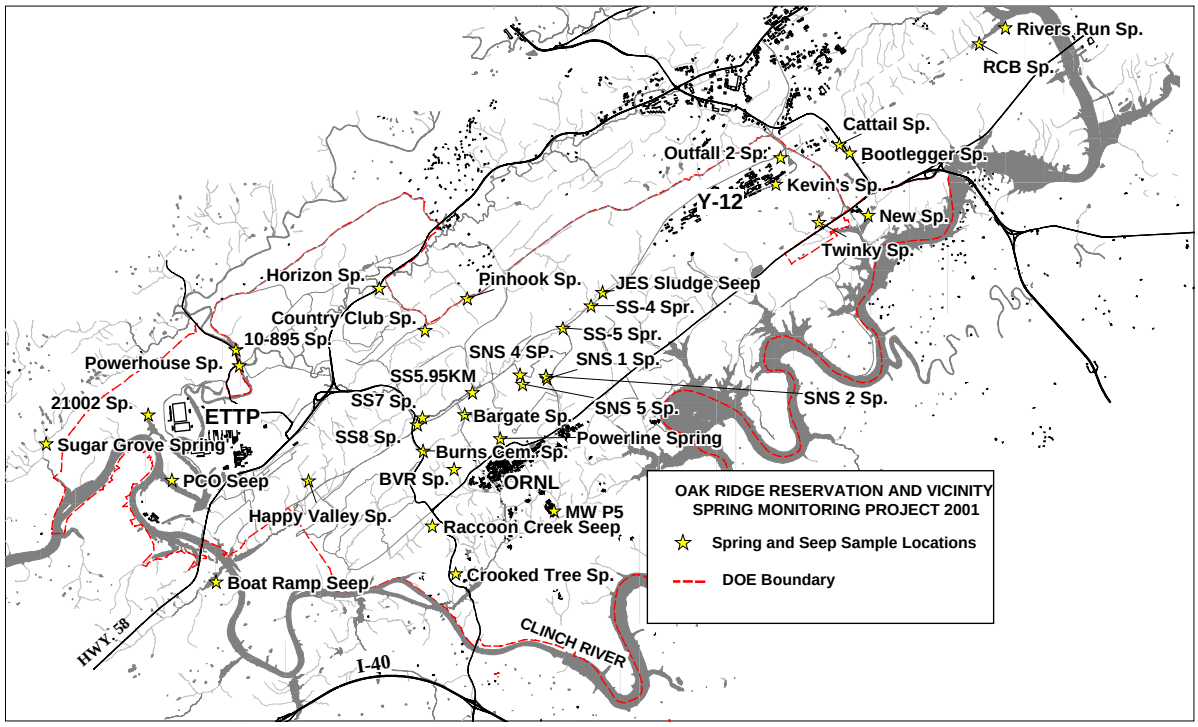

Figure 1 Calendar Year 2001 Sampling Locations for Spring and Seep Monitoring Project

Tables and Figures

Table 1 Locations that had no detectable Volatile Organic Compounds

Location Name	Spring 2001	Fall 2001
Bar Gate Spring		0
Boat Ramp Seep	0	
Burns Cemetery Spring	0	
BVR 1 Spring		0
Country Club Spring	0	
Crooked Tree Spring	0	
Happy Valley Spring	0	
MW P5 (monitoring Well)		0
New Spring	0	
Pinhook Spring	0	
Powerhouse Spring	0	
Powerline Spring	0	
Raccoon Creek Seep	0	
RCB Spring		0
Rivers Run Spring	0	
SNS 1 Spring	0	
SNS 2 Spring	0	
SNS 4 Spring		0
SNS 5 Spring		0
SS5.95KM Spring	0	
SS-7 Spring	0	
SS-8 Spring	0	
Sugar Grove Spring	0	
Twinky Spring		0

Table 2 Volatile Organic Compounds and the Maximum Contaminant Limit (MCL) based on Drinking Water Standards (2001).

All values in parts per million, J Qualifiers means that compound identified but not quantified, E Qualifiers means estimated					
PARAMETER	**Location Name**	**Spring**	**Lab Qualifier**	**Fall**	**Lab Qualifier**
1,1,1-Trichloroethane	21002 Sp.	0.0006		0.00163	
	Bootlegger Sp.	0.0011		0.0009	
MCL 0.20	JES Sludge Seep	0.0013			
	SS-4 Sp.			0.0004	J
1,1-Dichloroethane	Bootlegger Sp.	0.0013		0.0008	
	JES Sludge Seep	0.0038			
	SS-4 Sp.			0.0006	
1,1-Dichloroethene	21002 Sp.	0.0015		0.00392	
	Bootlegger Sp.	0.0006			
MCL 0.007	SS-4 Sp.			0.0024	
	SS-5 Sp.			0.0003	J
Benzene MCL 0.005	JES Sludge Seep	0.0012			
Carbon Tetrachloride	21002 Sp.	0.0028		0.00445	
MCL 0.005	Cattail Sp.	0.0015			
	USGS 10-895 Sp.	0.0015			
Chlorobenzene MCL 0.1	JES Sludge Seep	0.0018			
Chloroethane	JES Sludge Seep	0.0025			
Chloroform	21002 Sp.	0.0002		0.0005	
	Bootlegger Sp.			0.0003	J
	Outfall 2 Sp.	0.0005			
	SS-4 Sp.			0.0003	J
Cis-1,2-Dichloroethene	Bootlegger Sp.	0.0012		0.0018	
	JES Sludge Seep	0.114			
MCL 0.07	PCO Seep	0.0013			
	SS-4 Sp.	0.0004	J	0.0147	
	SS-5 Sp.			0.0016	
Methylene Chloride	SNS 1 Sp.			0.00055	
	SNS 2 Sp.			0.00277	
Tetrachloroethene	21002 Sp.	0.0002		0.00051	
	Bootlegger Sp.	0.0019		0.0023	
MCL 0.005	Cattail Sp.	0.0007		0.0001	J
	JES Sludge Seep	0.0003	J		
	Kevin's Sp.	0.0002	J		
	SS-4 Sp.	0.0002	J	0.0008	
	SS-5 Sp.			0.0002	J
Toluene	SNS 1 Sp.			0.0006	
MCL 1	SNS 2 Sp.			0.00476	
Trans-1,2-Dichloroethene	JES Sludge Seep	0.0006			
Trichloroethene	21002 Sp.	0.0199		0.0343	
	Bootlegger Sp.	0.0002	J	0.0002	J
MCL 0.005	Cattail Sp.	0.0022		0.0009	
	JES Sludge Seep	0.0018	E		
	PCO Seep	0.043	E		
	SS-4 Sp.	0.0038		0.0253	
	SS-5 Sp.	0.0002	J	0.0019	
	USGS 10-895 Sp.	0.0082		0.00845	
Trichlorofluormethane	Bootlegger Sp.	0.0007	J		
Vinyl Chloride MCL 0.002	JES Sludge Seep	0.0042			

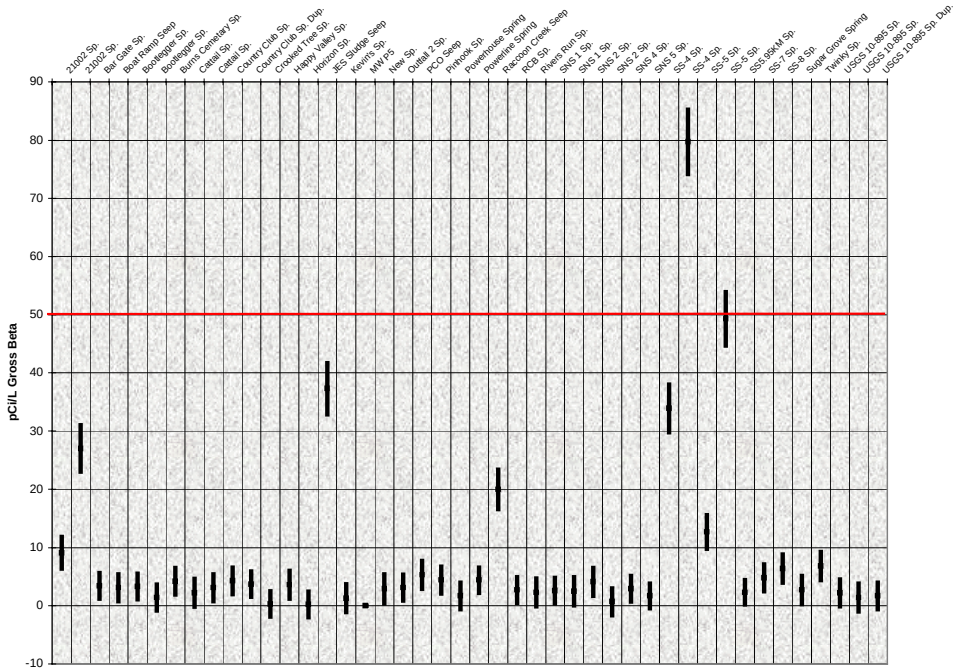

Figure 3 Gross Beta Spring and Fall Seasons of 2001. Heavy Line at 50 pCi/L for limit comparison

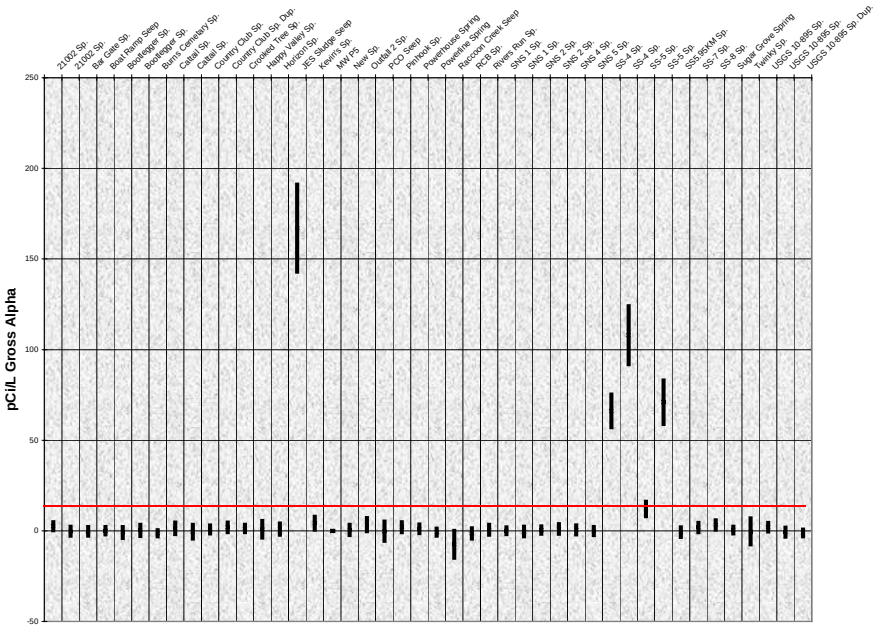

Figure 2 Gross Alpha in Spring and Fall Season of 2001. Heavy line at 15 pCi/L for limit comparison.

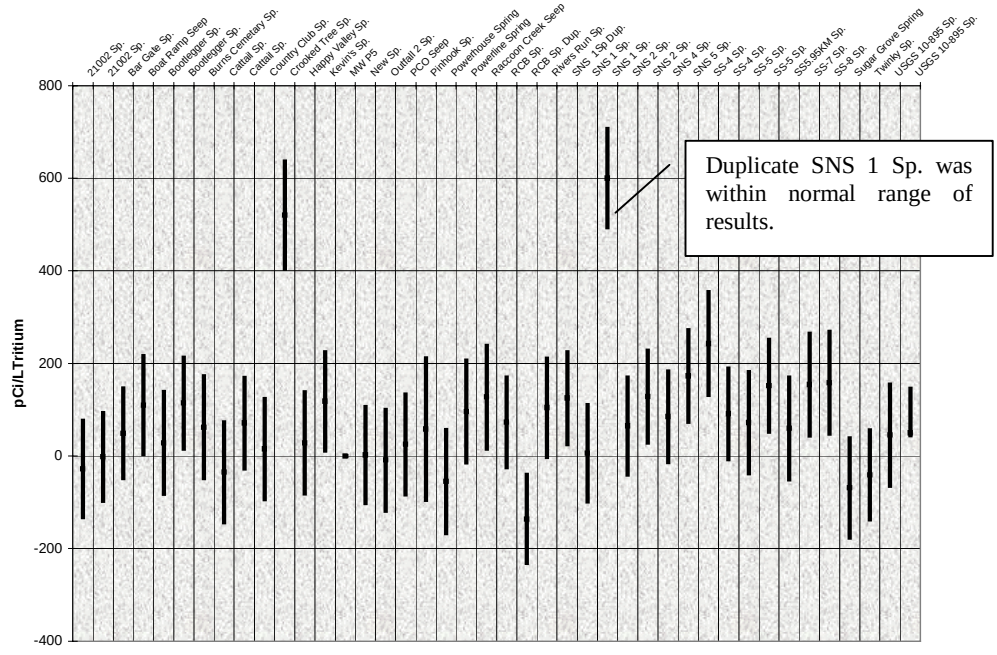

Figure 5 Tritium in Spring and Fall Season of 2001.

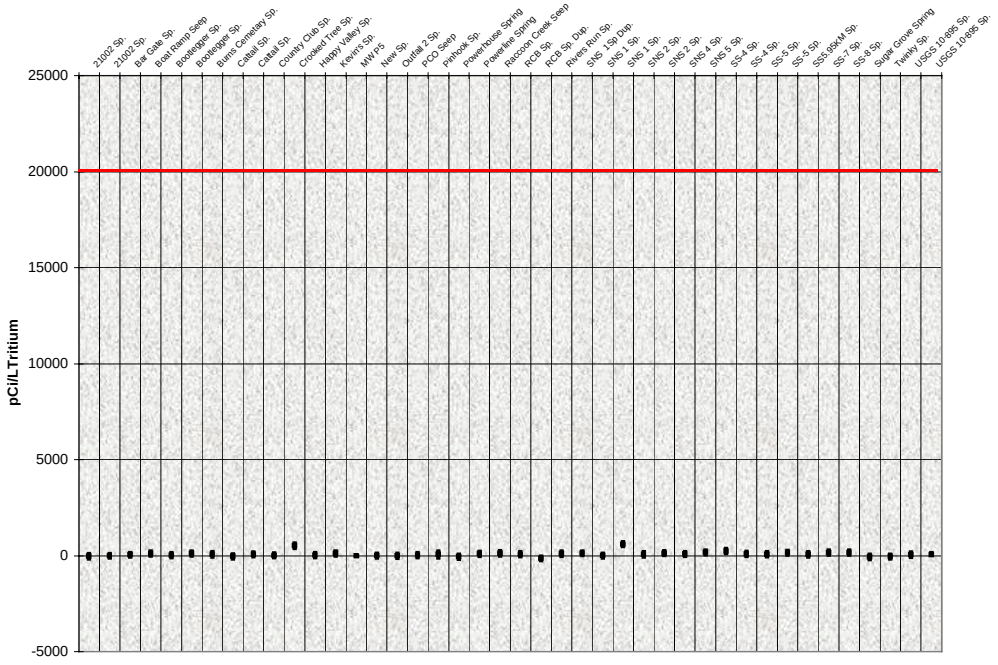

Figure 4 Tritium Results with 20,000 pCi/L Drinking Water Limit illustrated (2001).

Table 3 Summary of metals tested with Maximum Contaminant Levels (MCLs). U means result was below detection (2001).

Units ppm MCL	*Arsenic 0.05 ppm*		*Cadmium 0.005 ppm*		*Lead 0.05 ppm*		*Mercury 0.002 ppm*		*Nickel*	*Selenium 0.05 ppm*		*Thallium*		*Chromium 0.1 ppm Total*		*Uranium*		*Zinc 5.0 ppm*	
Location Name	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
21002 Sp.	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0.002	U		0.003	0.004
Bar Gate Sp.		U		U		U		U	U		U		U		U				0.003
Boat Ramp Seep	U		U		U		U			U		U				U		0.005	
Bootlegger Sp.	U	U	U	U	U	U	U	U	0.006	U	U	U	U	0.001	U	U		0.019	U
Burns Cemetery Sp.	U		U		U		U			U		U		U				0.005	
BVR 1 Sp.		U		U		U			U		U		U		U				0.002
Cattail Sp.	U	U	U	U	U	U	U	U	U	U	U	U	U	0.001	0.001	U		0.006	0.011
Country Club Sp.	U		U		U		U			U		U		U		U		0.003	
Crooked Tree Sp.	U		U		0.001		U			U		U		0.003		U		0.004	
Happy Valley Sp.	U		U		U		U			U		U		0.001		U		0.006	
Horizon Sp.	U		U		0.001		U			U		U		U		U			
JES Sludge Seep	0.002		U		U		U			U		U		U		0.335			
Kevin's Sp.	U		U		U		U			U		U		U		U		0.007	
MW P5		U		U		U		U	0.015		U		U		U		U		0.004
New Sp.	U		U		U		U			U		U		U		U		0.006	
Outfall 2 Sp.	U		U		U		U			U		U		0.001		U		0.023	
PCO Seep	U		U		0.001		U			U		U		0.001		U		0.008	
Pinhook Sp.	U		U		U		U			U		U		0.001				0.005	
Powerhouse Spring	U		U		U		U			U		U		U		U		0.002	
Powerline Spring	U		U		U		U			U		U		U		U		0.004	
Raccoon Creek Seep	U		U		U		U			U		U		0.001		U		0.008	
RCB Sp.		U		U		U		U	0.011		U		U		U				0.003
Rivers Run Sp.	U		U		0.002		U			U		U		0.002		U		0.01	
SNS 1 Sp.	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U		0.004	U
SNS 2 Sp.	U	U	U	U	U	U	U	U	U	U	U	U	U	0.001	U	U		0.007	0.003
SNS 4 Sp.		U		U		U		U	U		U		U		U				0.008
SNS 5 Sp.		U		U		U		U			U		U		0.001				0.014
SS-4 Sp.	U	U	U	U	U	U	U	U	0.013	U	U	U	U	0.001	U	0.09		0.008	0.005
SS-5 Sp.	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U		0.005	0.005
SS5.95KM Sp.	U		U		U		U			U		U		U		U		0.005	
SS-7 Sp.	U		U		U		U			U		U		U				0.003	
SS-8 Sp.	U		U		U		U			U		U		U		U		0.012	
Sugar Grove Spring	U		U		U		U			U		U		0.001		U		0.004	
Twinky Sp.		U		U		U		U	0.011		U		U		U				0.005
USGS 10-895 Sp.	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0.001	U		0.003	0.003

Appendix of all 2001 Groundwater Sample Results.

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
21002 Sp.	Inorganic	General Organics	Chloride	1.7	2		
			Dissolved Residue	111	110		
			NO3 & NO2 as Nitrogen	0.17	2.18		
			Suspended Residue	21	U		
			Total Alkalinity	111			
			Total Hardness		113		
		Metals	Arsenic	U	U		
			Cadmium	U	U		
			Lead	U	U		
			Mercury	U	U		
			Nickel	U			
			Selenium	U	U		
			Thallium	U	U		
			Total Chromium	0.002	U		
			Uranium		U		
			Zinc	0.004	0.003		
	Radiological	Alpha	Gross Alpha	-0.2	2.6	2.5	2.2
		Beta	Gross Beta	27	9.1	4	2.7
		Gamma	Bi-214	11.9		3.1	
		H-3	Tritium	1284	-28	115	104
	Organic	TCL Volatiles	1,1,1-Trichloroethane	0.00163	0.0006		
			1,1-Dichloroethene	0.00392	0.0015		
			Carbon Tetrachloride	0.00445	0.0028		
			Chloroform	0.0005	0.0002		
			Tetrachloroethene	0.00051	0.0002		
			Trichloroethene	0.0343	0.0199		
Bar Gate Sp.	Inorganic	General Organics	Chloride	2			
			NO3 & NO2 as Nitrogen	1.61			
			Sulfate	4			
			Suspended Residue	U			
			Total Alkalinity	156			
		Metals	Arsenic	U			
			Cadmium	U			
			Lead	U			
			Mercury	U			
			Nickel	U			
			Selenium	U			
			Thallium	U			
			Total Chromium	U			
			Zinc	0.003			
	Radiological	Alpha	Gross Alpha	-0.3		2.4	
		Beta	Gross Beta	3.4		2.2	
		Gamma	Bi-214	22.4		44.4	
			Pb-214	17.8		4.5	
		H-3	Tritium	49		97	
	Organic	TCL Volatiles	Volatiles Not Detected	U			
Boat Ramp Seep	Inorganic	General Organics	Chloride		4		
			Dissolved Residue		144		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			NO3 & NO2 as Nitrogen		0.4		
			Suspended Residue		U		
			Total Hardness		144		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Uranium		U		
			Zinc		0.005		
	Radiological	Alpha	Gross Alpha		0.1		2
		Beta	Gross Beta		3.1		2.3
		H-3	Tritium		110		106
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Bootlegger Sp.	Inorganic	General Organics	Chloride	3.5	5		
			Dissolved Residue		188		
			NO3 & NO2 as Nitrogen	0.44	0.51		
			Sulfate	5			
			Suspended Residue	U	U		
			Total Alkalinity	194			
			Total Hardness		191		
		Metals	Arsenic	U	U		
			Cadmium	U	U		
			Lead	U	U		
			Mercury	U	U		
			Nickel	0.006			
			Selenium	U	U		
			Thallium	U	U		
			Total Chromium	U	0.001		
			Uranium		U		
			Zinc	U	0.019		
	Radiological	Alpha	Gross Alpha	0.3	-0.9	3.1	3
		Beta	Gross Beta	1.4	3.3	2.2	2.2
		Gamma	Bi-214	43.4	14.6	4.7	3.4
			Pb-214	52.2	19.2	5.5	3.4
			Tl-208		3.9		1.2
		H-3	Tritium	114	28	98	110
	Organic	TCL Volatiles	1,1,1-Trichloroethane	0.0009	0.0011		
			1,1-Dichloroethane	0.0008	0.0013		
			1,1-Dichloroethene		0.0006		
			Chloroform	0.0003		J	
			Cis-1,2-Dichloroethene	0.0018	0.0012		
			Tetrachloroethene	0.0023	0.0019		
			Trichloroethene	0.0002	0.0002	J	J
			Trichlorofluormethane		0.0007		J
Burns Cemetary Sp.	Inorganic	General Organics	Chloride		1.9		
			Dissolved Residue		88		
			NO3 & NO2 as Nitrogen		0.6		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Suspended Residue		U		
			Total Hardness		88		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Zinc		0.005		
	Radiological	Alpha	Gross Alpha		-1.3		1.7
		Beta	Gross Beta		4.2		2.3
		Gamma	Bi-214		384		1.2
			Pb-214		418		11
		H-3	Tritium		62		110
	Organic	TCL Volatiles	Volatiles Not Detected		U		
BVR 1 Sp.	Inorganic	General Organics	Alkalinity as CaCo3	134			
			Chloride	2			
			Dissolved Residue	145			
			Suspended Residue	U			
		Metals	Arsenic	U			
			Cadmium	U			
			Lead	U			
			Nickel	U			
			Selenium	U			
			Thallium	U			
			Total Chromium	U			
			Zinc	0.002			
	Organic	TCL Volatiles	Volatiles Not Detected	U			
Cattail Sp.	Inorganic	General Organics	Chloride	4.7	4		
			Dissolved Residue		246		
			NO3 & NO2 as Nitrogen	0.97	1.61		
			Sulfate	20			
			Suspended Residue	17	63		
			Total Alkalinity	219			
			Total Hardness		238		
		Metals	Arsenic	U	U		
			Cadmium	U	U		
			Lead	U	U		
			Mercury	U	U		
			Nickel	U			
			Selenium	U	U		
			Thallium	U	U		
			Total Chromium	0.001	0.001		
			Uranium		U		
			Zinc	0.011	0.006		
	Radiological	Alpha	Gross Alpha	-0.4	1.4	3.8	3.2
		Beta	Gross Beta	3.1	2.2	2.3	2.4
		Gamma	Bi-214	35.4	23.9	4	4.3
			Pb-214	34	32.4	4.2	5.6

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
		H-3	Tritium	71	-35	98	108
	Organic	TCL Volatiles	Carbon Tetrachloride		0.0015		
			Tetrachloroethene	0.0001	0.0007	J	
			Trichloroethene	0.0009	0.0022		
Country Club Sp.	Inorganic	General Organics	Chloride		2.7		
			Dissolved Residue		123		
			NO3 & NO2 as Nitrogen		0.09		
			Suspended Residue		U		
			Total Hardness		106		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Uranium		U		
			Zinc		0.003		
	Radiological	Alpha	Gross Alpha		0.8		2.3
		Beta	Gross Beta		4.3		2.3
		Gamma	Bi-214		205		8.4
			Pb-214		216.5		8.6
		H-3	Tritium		15		108
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Country Club Sp. Dup.	Radiological	Alpha	Gross Alpha		2		2.6
		Beta	Gross Beta		3.7		2.2
Crooked Tree Sp.	Inorganic	General Organics	Chloride		2		
			Dissolved Residue		135		
			NO3 & NO2 as Nitrogen		0.04		
			Suspended Residue		25		
			Total Hardness		86		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		0.001		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		0.003		
			Uranium		U		
			Zinc		0.004		
	Radiological	Alpha	Gross Alpha		1.3		2
		Beta	Gross Beta		0.3		2.2
		Gamma	Bi-214		10.8		3.1
			Pb-214		18.2		3.8
		H-3	Tritium		520		116
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Happy Valley	Inorganic	General Organics	Chloride		1.9		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
Sp.							
			Dissolved Residue		295		
			NO3 & NO2 as Nitrogen		0.46		
			Suspended Residue		17		
			Total Alkalinity		157		
			Total Hardness		261		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		0.001		
			Uranium		U		
			Zinc		0.006		
	Radiological	Alpha	Gross Alpha		0.9		4.5
		Beta	Gross Beta		3.6		2.4
		Gamma	Bi-214		41.5		4.1
			Pb-214		23.7		3.8
		H-3	Tritium		28		109
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Horizon Sp.	Inorganic	General Organics	Chloride		5.3		
			Dissolved Residue		246		
			NO3 & NO2 as Nitrogen		0.81		
			Suspended Residue		27		
			Total Hardness		225		
		Metals	Arsenic		U		
			Cadmium		U		
			Calcium		70.6		
			Copper		U		
			Lead		0.001		
			Magnesium		4.7		
			Mercury		U		
			Potassium		1.03		
			Selenium		U		
			Sodium		2.2		
			Thallium		U		
			Total Chromium		U		
			Uranium		U		
	Radiological	Alpha	Gross Alpha		1		3
		Beta	Gross Beta		0.2		2.2
		Tc-99	Technetium 99		-0.3		1.2
	Organic	TCL Volatiles	Volatiles Not Detected		U		
JES Sludge Seep	Inorganic	General Organics	Chloride		39		
			Dissolved Residue		466		
			NO3 & NO2 as Nitrogen		0.05		
			Suspended Residue		12		
			Total Hardness		354		
		Metals	Arsenic		0.002		
			Cadmium		U		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Calcium		118		
			Lead		U		
			Magnesium		11.3		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Uranium		0.335		
	Radiological	Alpha	Gross Alpha		167		24
		Beta	Gross Beta		37.3		4.4
		Gamma	Bi-214		13.7		3.8
			Pb-214		23.7		3.9
			Tl-208		5.4		1.5
	Organic	TCL Volatiles	1,1,1-Trichloroethane		0.0013		
			1,1-Dichloroethane		0.0038		
			Benzene		0.0012		
			Chlorobenzene		0.0018		
			Chloroethane		0.0025		
			Cis-1,2-Dichloroethene		0.114		
			Tetrachloroethene		0.0003		J
			Trans-1,2-Dichloroethene		0.0006		
			Trichloroethene		0.0018		
			Vinyl Chloride		0.0042		
Kevin's Sp.	Inorganic	General Organics	Chloride		6.3		
			Dissolved Residue		263		
			NO3 & NO2 as Nitrogen		8.5		
			Suspended Residue		U		
			Total Hardness		260		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Uranium		U		
			Zinc		0.007		
	Radiological	Alpha	Gross Alpha		4.3		3.5
		Beta	Gross Beta		1.3		2.4
		Gamma	Bi-214		12.3		3.4
		H-3	Tritium		118		106
	Organic	TCL Volatiles	Tetrachloroethene		0.0002		J
MW P5	Inorganic	General Organics	Alkalinity as CaCo3	251			
			Chloride	4			
			Dissolved Residue	300			
			NO3 & NO2 as Nitrogen	U			
			Suspended Residue	U			
			Total Hardness	U			
		Metals	Arsenic	U			
			Cadmium	U			

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Lead	U			
			Mercury	U			
			Selenium	U			
			Thallium	U			
			Total Chromium	U			
			Nickel	15			
			Zinc	4			
	Radiological	Alpha	Gross Alpha	3		6.1	
		Beta	Gross Beta	2.6		2.4	
		Gamma	Bi-212	36.2		4.2	
		H-3	Tritium	22853		278	
	Organic	TCL Volatiles	Volatiles Not Detected	U			
MW P5 Dup.	Radiological	Alpha	Gross Alpha	11.7		8	
		Beta	Gross Beta	2.7		2.4	
MW P1	Radiological	Alpha	Gross Alpha	0.2		3.5	
		Beta	Gross Beta	1.2		2.5	
		Tritium	H-3	452		110	
		Gamma	Gama			NDA	
New Sp.	Inorganic	General Organics	Chloride		2.2		
			Dissolved Residue		226		
			NO3 & NO2 as Nitrogen		0.72		
			Suspended Residue		U		
			Total Hardness		208		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Uranium		U		
			Zinc		0.006		
	Radiological	Alpha	Gross Alpha		0.6		2.8
		Beta	Gross Beta		2.9		2.5
		H-3	Tritium		2		104
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Outfall 2 Sp.	Inorganic	General Organics	Chloride		18		
			Dissolved Residue		187		
			NO3 & NO2 as Nitrogen		0.99		
			Suspended Residue		U		
			Total Hardness		151		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		0.001		
			Uranium		U		
			Zinc		0.023		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
	Radiological	Alpha	Gross Alpha		3.4		3.6
		Beta	Gross Beta		3.1		2.2
		Gamma	Bi-214		12		2.9
		H-3	Tritium		-9		109
	Organic	TCL Volatiles	Chloroform		0.0005		
PCO Seep	Inorganic	General Organics	Chloride		3.5		
			Dissolved Residue		437		
			NO3 & NO2 as Nitrogen		0.3		
			Suspended Residue		28		
			Total Alkalinity		380		
			Total Hardness		426		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		0.001		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		0.001		
			Uranium		U		
			Zinc		0.008		
	Radiological	Alpha	Gross Alpha		-0.2		5.3
		Beta	Gross Beta		5.3		2.4
		Gamma	Bi-214		33.8		5.3
			Pb-214		31		4.4
		H-3	Tritium		25		108
	Organic	TCL Volatiles	Cis-1,2-Dichloroethene		0.0013		
			Trichloroethene		0.043		
Pinhook Sp.	Inorganic	General Organics	Chloride		2.9		
			Dissolved Residue		151		
			NO3 & NO2 as Nitrogen		0.34		
			Suspended Residue		U		
			Total Hardness		0.136		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		0.001		
			Zinc		0.005		
	Radiological	Alpha	Gross Alpha		2.1		2.8
		Beta	Gross Beta		4.4		2.3
		Gamma	Bi-214		94.7		6.3
			Pb-214		91.8		6
		H-3	Tritium		58		153
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Powerhouse Spring	Inorganic	General Organics	Chloride		5.3		
			Dissolved Residue		183		
			NO3 & NO2 as Nitrogen		0.63		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Suspended Residue		U		
			Total Hardness		191		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Uranium		U		
			Zinc		0.002		
	Radiological	Alpha	Gross Alpha		1.1		2.4
		Beta	Gross Beta		1.7		2.3
		Gamma	Bi-214		74.4		5.3
			Pb-214		62.5		4.9
		H-3	Tritium		-55		111
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Powerline Spring	Inorganic	General Organics	Chloride		3.2		
			Dissolved Residue		113		
			NO3 & NO2 as Nitrogen		0.25		
			Suspended Residue		U		
			Total Hardness		114		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Uranium		U		
			Zinc		0.004		
	Radiological	Alpha	Gross Alpha		-0.7		2
		Beta	Gross Beta		4.4		2.2
		Gamma	Bi-214		101.6		6.3
			Pb-214		95.2		6
		H-3	Tritium		96		110
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Raccoon Creek Seep	Inorganic	General Organics	Chloride		7.9		
			Dissolved Residue		331		
			NO3 & NO2 as Nitrogen		0.07		
			Suspended Residue		45		
			Total Hardness		296		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Total Chromium		0.001		
			Uranium		U		
			Zinc		0.008		
	Radiological	Alpha	Gross Alpha		-7.4		-7.4
		Beta	Gross Beta		20		3.4
		H-3	Tritium		127		111
	Organic	TCL Volatiles	Volatiles Not Detected		U		
RCB Sp.	Inorganic	General Organics	Chloride	14.9			
			Dissolved Residue	442			
			NO3 & NO2 as Nitrogen	1.81			
			Sulfate	179			
			Suspended Residue	U			
			Total Alkalinity	188			
		Metals	Arsenic	U			
			Cadmium	U			
			Lead	U			
			Mercury	U			
			Nickel	0.011			
			Selenium	U			
			Thallium	U			
			Total Chromium	U			
			Zinc	0.003			
	Radiological	Alpha	Gross Alpha	-1.4		2.9	
		Beta	Gross Beta	2.7		2.2	
		H-3	Tritium	73		97	
	Organic	TCL Volatiles	Volatiles Not Detected	U			
RCB Sp. Dup.	Radiological	H-3	Tritium	-136		95	
Rivers Run Sp.	Inorganic	General Organics	Chloride		3.3		
			Dissolved Residue		199		
			NO3 & NO2 as Nitrogen		0.07		
			Suspended Residue		14		
			Total Hardness		0.207		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		0.002		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		0.002		
			Uranium		U		
			Zinc		0.01		
	Radiological	Alpha	Gross Alpha		0.7		2.7
		Beta	Gross Beta		2.3		2.4
		H-3	Tritium		104		106
	Organic	TCL Volatiles	Volatiles Not Detected		U		
SNS 1Sp Dup.	Radiological	H-3	Tritium	125		99	
SNS 1 Sp.	Inorganic	General Organics	Chloride	2.4	2.5		
			Dissolved Residue	167	110		
			NO3 & NO2 as Nitrogen	0.19	0.1		
			Suspended Residue	U	U		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Total Alkalinity	173			
			Total Hardness		115		
		Metals	Arsenic	U	U		
			Cadmium	U	U		
			Lead	U	U		
			Mercury	U	U		
			Nickel	U			
			Selenium	U	U		
			Thallium	U	U		
			Total Chromium	U	U		
			Uranium		U		
			Zinc	U	0.004		
	Radiological	Alpha	Gross Alpha	-0.4	0.1	2.6	1.8
		Beta	Gross Beta	2.5	2.6	2.4	2.2
		Gamma	Bi-214	14.1	17.3	1.4	3.6
			Tl-208	5.2		1.4	
		H-3	Tritium	600	6	106	104
	Organic	TCL Volatiles	Methylene Chloride	0.00055			
			Toluene	0.0006			
			Volatiles Not Detected		U		
SNS 2 Sp.	Inorganic	General Organics	Chloride	1.5	2		
			Dissolved Residue	143	132		
			NO3 & NO2 as Nitrogen	0.18	0.06		
			Suspended Residue	45	20		
			Total Alkalinity	148			
			Total Hardness		140		
		Metals	Arsenic	U	U		
			Cadmium	U	U		
			Lead	U	U		
			Mercury	U	U		
			Nickel	U			
			Selenium	U	U		
			Thallium	U	U		
			Total Chromium	U	0.001		
			Uranium		U		
			Zinc	0.003	0.007		
	Radiological	Alpha	Gross Alpha	1	0.4	2.6	2
		Beta	Gross Beta	0.7	4.1	2.3	2.4
		Gamma	Gamma	U			
			Tl-208		5.7		1.6
		H-3	Tritium	128	65	99	105
	Organic	TCL Volatiles	Methylene Chloride	0.00277			
			Toluene	0.00476			
			Volatiles Not Detected		U		
SNS 4 Sp.	Inorganic	General Organics	Chloride	1.9			
			NO3 & NO2 as Nitrogen	2.91			
			Sulfate	7			
			Suspended Residue	12			
			Total Alkalinity	149			
		Metals	Arsenic	U			

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Cadmium	U			
			Lead	0.002			
			Mercury	U			
			Nickel	U			
			Selenium	U			
			Thallium	U			
			Total Chromium	U			
			Zinc	0.008			
	Radiological	Alpha	Gross Alpha	0.6		2.5	
		Beta	Gross Beta	2.9		2.2	
		Gamma	Bi-214	27		4.2	
			Pb-214	24.2		3.9	
		H-3	Tritium	85		98	
	Organic	TCL Volatiles	Volatiles Not Detected	U			
SNS 5 Sp.	Inorganic	General Organics	Chloride	1.8			
			NO3 & NO2 as Nitrogen	2.10			
			Sulfate	4			
			Suspended Residue	21			
			Total Alkalinity	136			
		Metals	Arsenic	U			
			Cadmium	U			
			Lead	U			
			Mercury	U			
			Selenium	U			
			Thallium	U			
			Total Chromium	0.001			
			Zinc	0.014			
	Radiological	Alpha	Gross Alpha	-0.1		2.2	
		Beta	Gross Beta	1.7		2.1	
		Gamma	Bi-214	27.4		4.1	
			Pb-214	12.3		3.2	
		H-3	Tritium	173		99	
	Organic	TCL Volatiles	Volatiles Not Detected	U			
SS-4 Sp.	Inorganic	General Organics	Chloride	41.3	13.6		
			Sulfate	33			
			Dissolved Residue		210		
			NO3 & NO2 as Nitrogen	22.1	6.2		
			Suspended Residue	U			
			Total Alkalinity	283			
			Total Hardness		181		
		Metals	Arsenic	U	U		
			Cadmium	U	U		
			Lead	U	U		
			Mercury	U	U		
			Nickel	0.0013			
			Selenium	U	U		
			Thallium	U	U		
			Total Chromium	U	0.001		
			Uranium		0.09		
			Zinc	0.005	0.008		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
	Radiological	Alpha	Gross Alpha	108	66.2	16	9
		Beta	Gross Beta	79.7	33.9	5.5	4.1
		Gamma	Bi-214	22.6	34.7	4	3.9
			Pb-214	12.8	32.9	3.7	3.7
		H-3	Tritium	91	243	98	111
	Organic	TCL Volatiles	1,1,1-Trichloroethane	0.0004		J	
			1,1-Dichloroethane	0.0006			
			1,1-Dichloroethene	0.0024			
			Chloroform	0.0003		J	
			Cis-1,2-Dichloroethene	0.0147	0.0004		J
			Tetrachloroethene	0.0008	0.0002		J
			Trichloroethene	0.0253	0.0038		
SS-5 Sp.	Inorganic	General Organics	Chloride	23.4	6.8		
			Dissolved Residue		143		
			NO3 & NO2 as Nitrogen	1.32	1.59		
			Sulfate	23			
			Suspended Residue	U	U		
			Total Alkalinity	219			
			Total Hardness		131		
		Metals	Arsenic	U	U		
			Cadmium	U	U		
			Lead	U	U		
			Mercury	U	U		
			Nickel	U			
			Selenium	U	U		
			Thallium	U	U		
			Total Chromium	U	U		
			Uranium		U		
			Zinc	0.005	0.005		
	Radiological	Alpha	Gross Alpha	71	12.1	12	4
		Beta	Gross Beta	49.3	12.7	4.6	2.9
		Gamma	Bi-214	31.4	128.2	4.3	6.9
			Pb-214	33.2	111	3.9	6.6
		H-3	Tritium	152	72	99	109
	Organic	TCL Volatiles	1,1-Dichloroethene	0.0003		J	
			Cis-1,2-Dichloroethene	0.0016			
			Tetrachloroethene	0.0002		J	
			Trichloroethene	0.0019	0.0002		J
SS5.95KM Sp.	Inorganic	General Organics	Chloride		2.9		
			Dissolved Residue		174		
			NO3 & NO2 as Nitrogen		0.07		
			Suspended Residue		U		
			Total Hardness		187		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Uranium		U		
			Zinc		0.005		
	Radiological	Alpha	Gross Alpha		-0.7		2.6
		Beta	Gross Beta		2.3		2.1
		Gamma	Bi-214		99.2		5.4
			Pb-214		99.5		6.2
		H-3	Tritium		60		110
	Organic	TCL Volatiles	Volatiles Not Detected		U		
SS-7 Sp.	Inorganic	General Organics	Chloride		6.5		
			Dissolved Residue		125		
			NO3 & NO2 as Nitrogen		0.15		
			Suspended Residue		U		
			Total Hardness		119		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Zinc		0.003		
	Radiological	Alpha	Gross Alpha		1.9		2.5
		Beta	Gross Beta		4.8		2.3
		Gamma	Bi-214		132.5		7.2
			Pb-214		122.3		6.4
		H-3	Tritium		154		110
	Organic	TCL Volatiles	Volatiles Not Detected		U		
SS-8 Sp.	Inorganic	General Organics	Chloride		4.1		
			Suspended Residue		U		
			Total Hardness		84		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		U		
			Uranium		U		
			Zinc		0.012		
	Radiological	Alpha	Gross Alpha		3.3		2.5
		Beta	Gross Beta		6.4		2.4
		Gamma	Bi-214		39.5		5.2
			Pb-214		33.8		5
		H-3	Tritium		158		110
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Sugar Grove Spring	Inorganic	General Organics	Chloride		3.6		
			Dissolved Residue		107		
			NO3 & NO2 as Nitrogen		0.54		
			Suspended Residue		14		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Total Hardness		107		
		Metals	Arsenic		U		
			Cadmium		U		
			Lead		U		
			Mercury		U		
			Selenium		U		
			Thallium		U		
			Total Chromium		0.001		
			Uranium		U		
			Zinc		0.004		
	Radiological	Alpha	Gross Alpha		0.4		1.9
		Beta	Gross Beta		2.7		2.4
		Gamma	Bi-214		40.6		4.6
			Pb-214		28.6		3.8
		H-3	Tritium		-69		107
	Organic	TCL Volatiles	Volatiles Not Detected		U		
Twinky Sp.	Inorganic	General Organics	Chloride	3.3			
			Dissolved Residue	235			
			NO3 & NO2 as Nitrogen	3.1			
			Sulfate	10			
			Suspended Residue	11			
			Total Alkalinity	196			
		Metals	Arsenic	U			
			Cadmium	U			
			Lead	U			
			Mercury	U			
			Nickel	0.011			
			Selenium	U			
			Thallium	U			
			Total Chromium	U			
			Zinc	0.005			
	Radiological	Alpha	Gross Alpha	-0.3		7.1	
		Beta	Gross Beta	6.8		2.4	
		H-3	Tritium	-41		96	
	Organic	TCL Volatiles	Volatiles Not Detected	U			
USGS 10-895 Sp.	Inorganic	General Organics	Chloride	2.1	2.4		
			Dissolved Residue	177	143		
			NO3 & NO2 as Nitrogen	0.21	0.55		
			Suspended Residue	40	U		
			Total Alkalinity	161	142		
			Total Hardness		148		
		Metals	Arsenic	U	U		
			Cadmium	U	U		
			Lead	U	U		
			Mercury	U	U		
			Nickel	U			
			Selenium	U	U		
			Thallium	U	U		
			Total Chromium	0.001	U		

Results in Parts Per Million or Picocuries per Liter for Radiological Analysis U = Undetected in Sample J = Estimated Value						+/- Error Lab Qualifier	
Location Name	Analysis	Parameter group	PARAMETER	Dry Season	Wet Season	Dry	Wet
			Uranium		U		
			Zinc	0.003	0.003		
	Radiological	Alpha	Gross Alpha	-0.7	2.1	2.5	2.4
		Beta	Gross Beta	1.4	2.2	2.4	2.3
		Gamma	Bi-214	12.3	132.1	3.1	7.1
			Pb-214		145.2		6.9
		H-3	Tritium	8244	45	183	109
	Organic	TCL Volatiles	Carbon Tetrachloride		0.0015		
			Trichloroethene	0.00845	0.0082		
USGS 10-895 Sp. Dup.	Radiological	Alpha	Gross Alpha		-1.1		1.9
		Beta	Gross Beta		1.7		2.3

Chapter 6 GROUNDWATER MONITORING

Groundwater Tracing Using Fluorescent Dyes to Spring SS-5 in Bear Creek Valley near the Y-12 Nuclear Weapons Plant and the Spallation Neutron Source construction site

Principal Author: Robert C. Benfield

Abstract

Very near the center of the Department of Energy Oak Ridge Reservation by the Anderson and Roane Counties boundary the bedrock spring SS-5 flows into Bear Creek. The Spring SS-5 contains elevated levels of radionuclides and organic compounds associated with waste generated from weapons production at the Y-12 plant. A hydrogeologic investigation of SS-5 to determine groundwater flow from Chestnut Ridge and Bear Creek Valley was initiated to improve monitoring for the new Spallation Neutron Source facility and the Y-12 plant. Two traces from a swallet hole usually taking all the flow in Bear Creek and two traces from an artificial sinkhole at the Spallation Neutron Source during 2001 were successful with the recovery of dye in water samples at SS-5 spring.

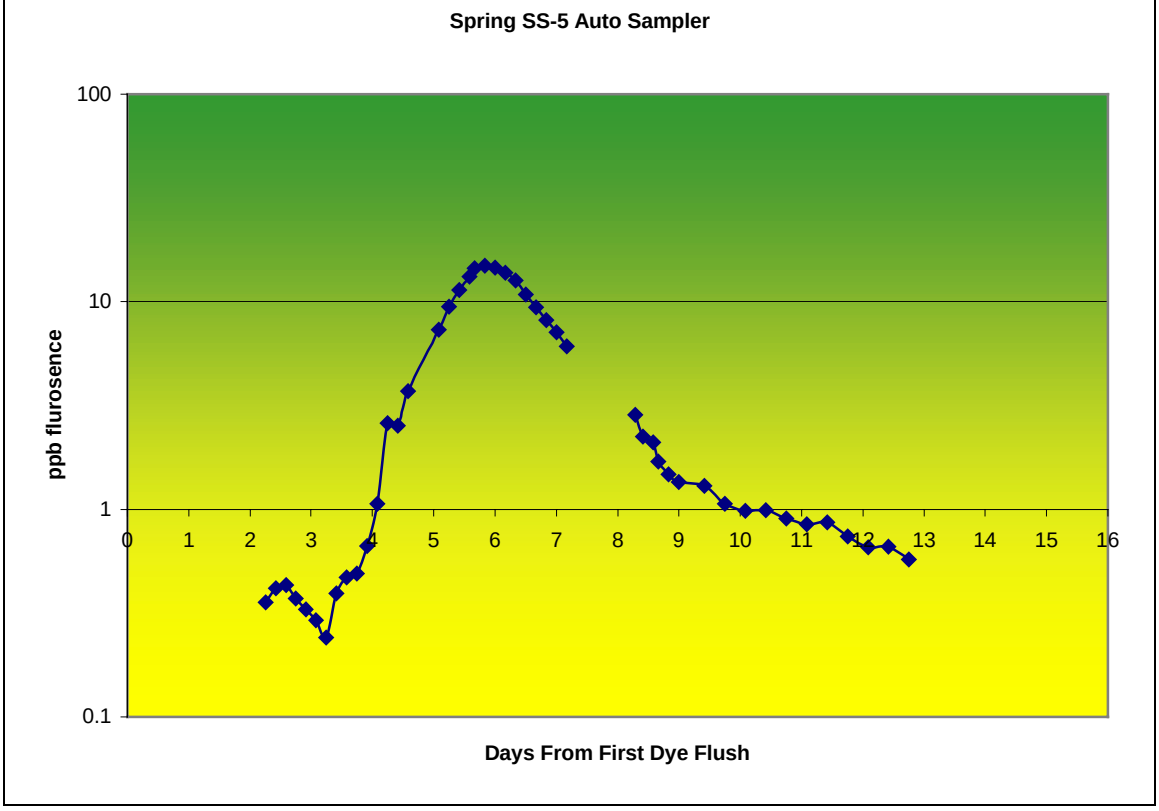

Figure 1 Swallet in Bear Creek dye flush on May 16, 2001

Introduction

This project is a part of the Basin Delineation work plan and serves to assist in monitoring for Y-12 and the Spallation Neutron Source. The two named hydrogeologic regimes Chestnut Ridge and Bear Creek Valley come together at the SS-5 spring. Interest in this spring is due to the current load of uranium and volatile organic compounds. For future restoration actions of groundwater in this area under the Federal Facilities Agreement, this report illustrates the complex hydrologic regime characteristics.

Methods and Materials

In the spring of 2001 field activities by the sate of Tennessee DOE-Oversight Division found a

Figure 2 Swallet in Bear Creek dye flush on May 16, 2001

karst feature called a swallet. This swallet is located in the upper reaches of Bear Creek, near SS-2 Spring (Figure 2). At this location, the entire flow of Upper Bear Creek sinks into a small swallow hole (swallet) along the stream bank. Below this swallet, Bear Creek is a dry streambed, until flow resumes downstream from tributary streams. On May 16, 2001,100 grams of 75.9% fluorescein (AY-73) was flushed in the swallet in the streambed of Bear Creek (Figure 2).

Monitoring of select springs and Bear Creek continued after the dye was flushed with creek water. ISCO 3700 automated samplers were set up at SS-4, SS-5 Springs and Bear Creek where SS-8 Spring joins Bear Creek near the weir. On May 17, 2001 at 10:40 AM, approximately 25 hours later, very visible fluorescein dye was observed in SS-4 Spring (Figure 3). The visual fluorescein in SS-4 Spring was observed to flow downstream below the confluence with Bear Creek. The fluorescein dye then sank in a second swallet, approximately 600 feet downstream from the confluence of SS-4 Spring and Bear Creek (Figure 8).

On May 21, 2001, a visual conformation of fluorescent dye was observed in SS-5 Spring. SS-5 spring(s) contains two resurgent connected pools of groundwater. Dye was observed in the north pool next to Bear Creek Road. No other visuals of the fluorescent dye were observed in springs downstream of SS 5 Spring.

A second groundwater trace was performed June 26, 2001. The object of the second trace was to

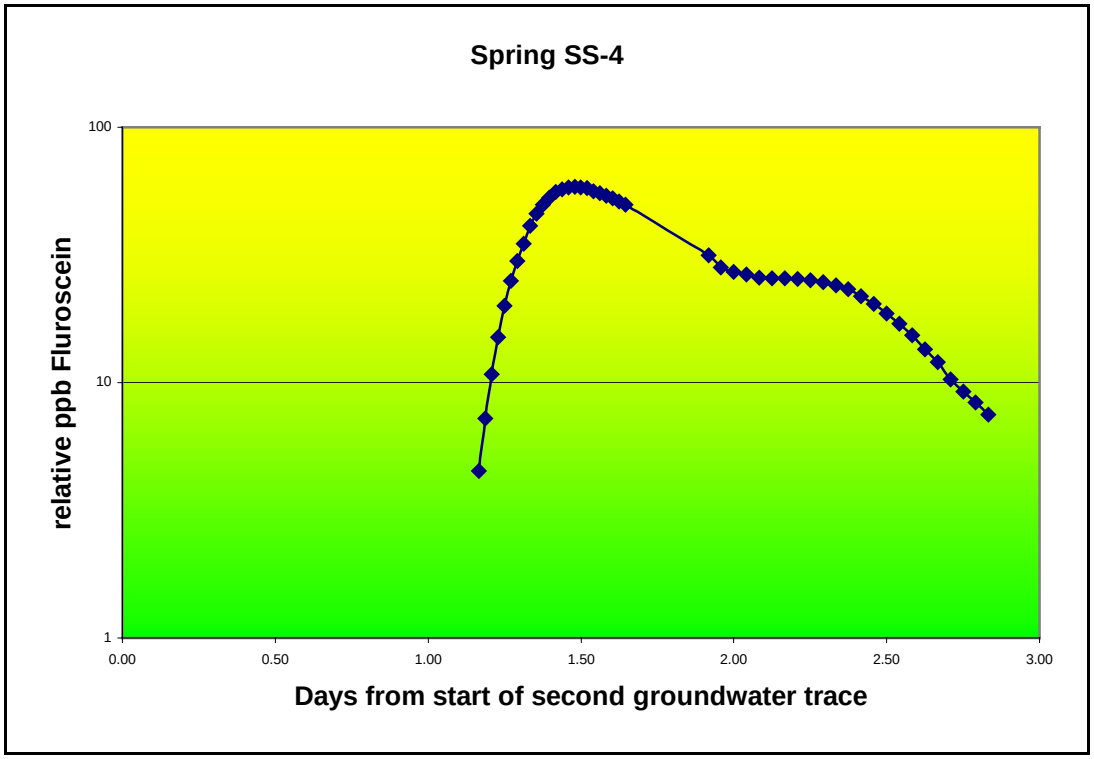

Figure 3 Dye Recovery in water samples in about 1 day travel time after June 26, 2001

determine if the second swallet 600 feet below the confluence of SS-4 and Bear Creek was connected to SS-5. Based on rapid flow from the swallet to SS-4 in both traces the dye sinking near SS-5 should travel to SS-5 in a few hours. It is evident that the second swallet did not connect with SS-5 under these groundwater conditions in 2001. The dye took a groundwater route of about 4 days for first arrival from the first swallow hole as in the May 16, 2001 trace (Figure 1).

Two more groundwater traces to SS-5 were performed from the future Spallation Neutron Source (SNS) being constructed on Chestnut Ridge to the south. These traces were prompted by a sudden collapse of soil in the ring structure of the SNS facility. Spring SS-5 was seen to flow turbid after a large storm (Figure 4). On July 30, 2001, during a field visit, TDEC-DOE-O observed water extremely turbid with sediments only characteristic of Chestnut Ridge. TDEC-DOE-O had never seen turbidity this extreme, during frequent site visits from 1992 to 2001.

Observation of the doughnut shaped facility revealed a collapse in the northwest sector of this ring structure area. The collapse was circular in shape and approximately 7 meters (25 feet) in diameter and collapsed to approximately 0.1 meters (6 inches) in the deepest location. At this

Figure 4 SS-5 Spring under turbid conditions after soil collapse at SNS Facility July 2001.

location a circular hole was observed, approximately 1 meter (3 feet) in diameter and a depth unknown as resembled in an expected cave entrance. Surface water had been flowing into this opening during storm events. Next to the collapse area another open hole was noted by a sandstone pinnacle, which had been exposed during construction activities. It was speculated that surface water had been washing around this pinnacle and entering the subsurface. This pinnacle appears to be along the contact of the Copper Ridge and Chepultepec members of the Knox formation.

On August 9, 2001, a site visit was conducted to the SNS site (Figure 7) to conduct pre flush test on the collapsed feature in the donut ring area. A 3500-gallon water truck was used to perform this test. A five-inch diameter hose connected to the water truck was placed in the open cave like entrance in the collapsed area. The contents of the 3500-gallon water truck were emplaced into this opening over a period of 27 minutes. All of the water in the water truck flowed into the subsurface with no overflow on the surface.

On August 13, 2001, 338 grams of liquid Rhodamine dye at 20 per cent concentrate (67 grams active ingredient) was emplaced into the open cave like entrance in the circular collapsed area. This dye was flushed into the subsurface with 3500 gallons of potable water.

Figure 5 Spallation Neutron Source artificial sinkhole August 14, 2001

On August 15, 2001, 400 grams of fluorescein powder 75 percent dye concentrate was flushed into the SNS target circular collapsed area. Prior to dye flush, the entire collapsed area had been excavated using a track hoe. The excavation was approximately 30 feet in diameter and 25 feet deep (Figure 5). This dye was flushed into the excavation and the subsurface with 3500 gallons of potable water, which was provided by a water truck. The potable water and dye was emplaced into the excavation over a period of 21 minutes. During this period no water was standing in the bottom of the excavation.

Immediately after dye emplacement, an ISCO automated sampler was set up at SS-5 Spring. Vials of water were picked up at springs in Bear Creek Valley and Bethel Valley (Figure 8). Bear Creek springs sampled included SS-4, Two Toes, Red Tail SS-6E, SS-6W, SS-5.95 KM, SS-7 and SS-8 (Figure 10). Bethel Valley springs sampled for dye included Powerline, Graphite Reactor, Concrete Box 2 and Bootlegger Springs.

Results and Discussion

A strong visual indication of dye was observed in SS-5 Spring on August 22, 2001, approximately 9 days from the emplacement of the Rhodamine and 7 days from the emplacement of the fluorescein dyes. This visual indication was green in color and appeared to be fluorescein. Upon spectrofluorometric analysis it appears both dyes mixed in the vadose zone and emerged in SS-5 with the red peak of Rhodamine shifted towards the green spectrum by deaminoalkalation of the dye (Figure 9).

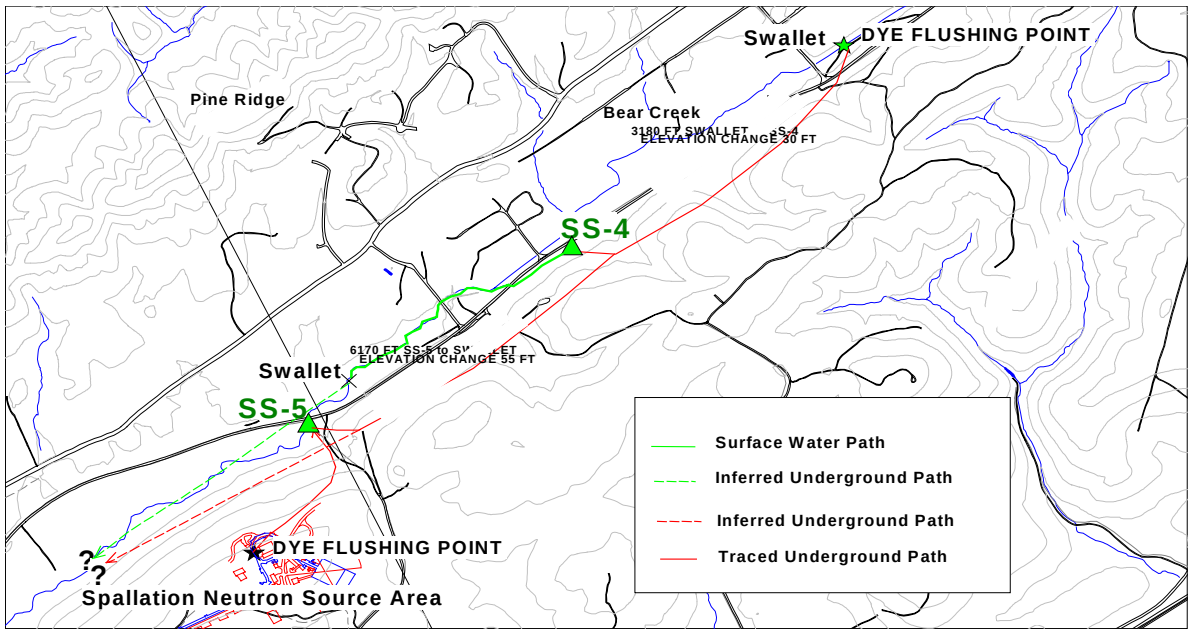

Figure 7 Dye Trace Locations calendar year 2001.

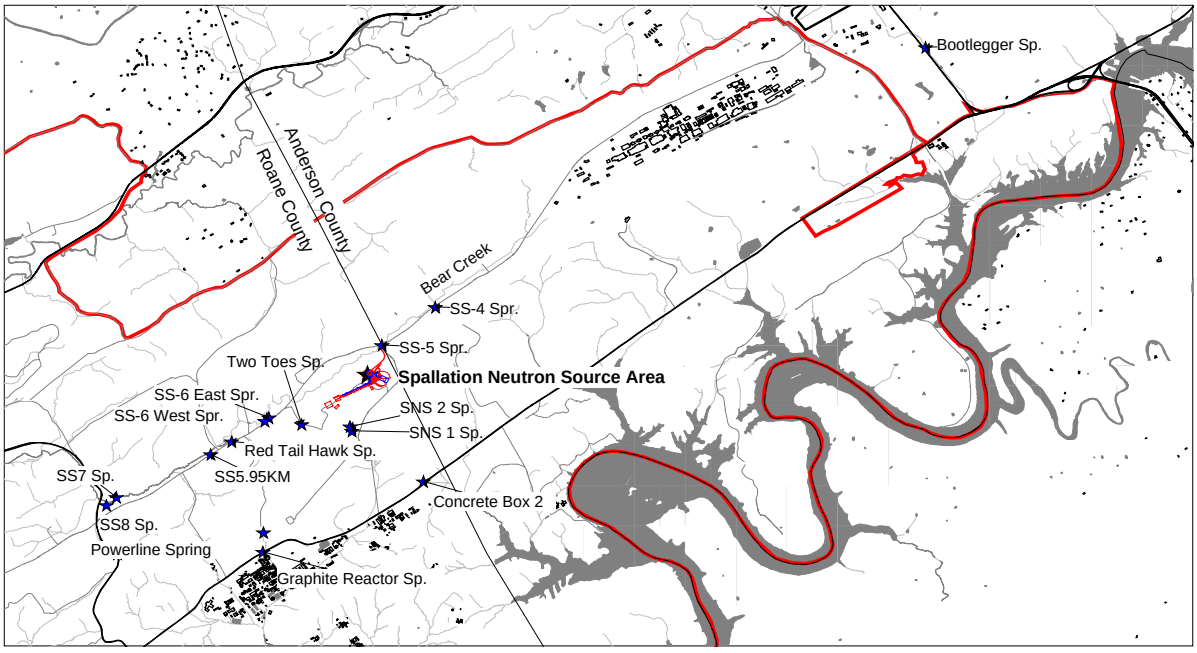

Figure 8 Springs Monitored during Groundwater Traces calendar 2001.

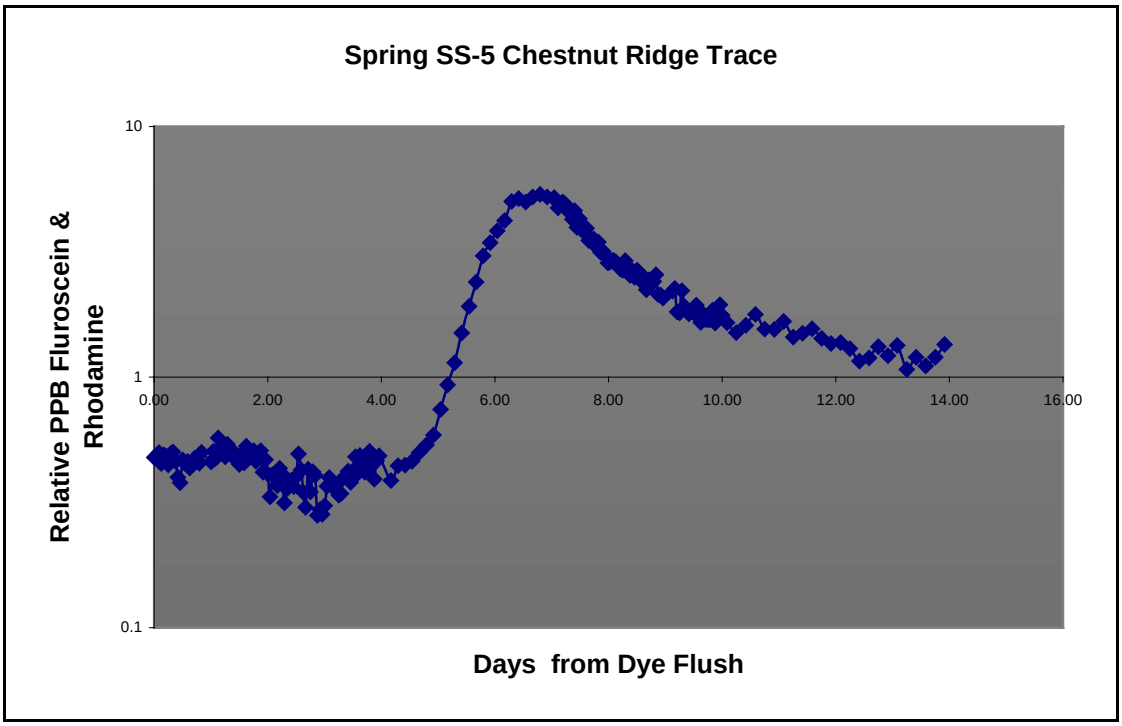

Figure 9 Groundwater trace results from dye flush started on August 13, 2001 at the Spallation Neutron Source Facility

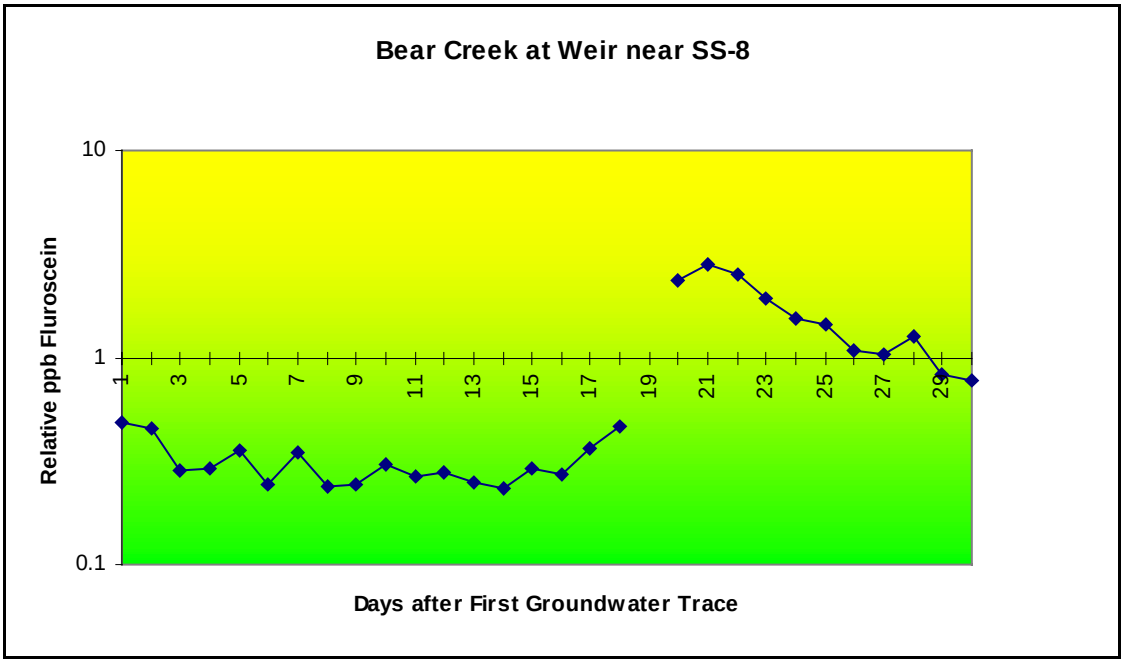

Figure 10 Recovery of dye in Bear Creek near SS-8 spring after May 12, 2001.

Conclusion

Groundwater tracing is a useful tool in developing an understanding of the rapid flow and how different basins are connected. These tests give evidence for the connection between the Chestnut Hydrogeologic Regimes and that of Bear Creek at SS-5. The flow directions are opposite for each of these regimes. Chestnut Ridge flows to the northeast and Bear Creek flows towards the southeast. The spring SS-5 is a major discharge point in Bear Creek and for Chestnut Ridge under specific flow conditions. The new Spallation Facility will create activated soils (radioactive) and monitoring for the transport of these activated soils at SS-5 is important in protecting human health and the environment.

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Chapter 7 RADIOLOGICAL MONITORING

Oak Ridge Reservation Facility Survey Program

Principal Author: David Thomasson

Abstract

Like other Department of Energy (DOE) sites across the nation, the Oak Ridge Reservation (ORR) released large quantities of radiological and chemical contamination into the environment during nearly five decades of nuclear weapons research and development. In response to this legacy, the Department of Energy Oversight Division (DOE-O) of the Tennessee Department of Environment and Conservation (TDEC) developed a Facility Survey Program (FSP) in 1994 to characterize the overall condition of facilities on the ORR. This characterization documents their physical condition, inventories of hazardous chemical and radioactive materials, process history, levels of contamination, and present-day potential for release of contaminants to the environment. Both active and inactive facilities are evaluated under varying scenarios ranging from catastrophic (i.e. tornado) to normal everyday working situations. Such a broad-based assessment supports the objectives of Section 1.2.3 of the *Tennessee Oversight Agreement*, which was designed to inform local citizens and governments of the historic and present-day nature of all operations on the ORR. This information is also essential for local emergency planning purposes. Since 1994 the division's survey team has characterized 160 facilities and found that about thirty percent pose a relatively high potential for release of contaminants to the environment. In many cases, this high potential for release relates to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or ventilation ductwork). During 2001 the survey team evaluated 17 facilities and found that 8 posed a high potential for environmental release. Two of these facilities were at Y-12 (Y-9204-3, Y-9213); four were at ORNL (X-3504, 3592, 2531, 3026); and two were at K-25 (K-1004-A, 1004-B). Since the inception of the program, corrective actions completed by DOE have removed seven facilities from the division's list of "high" Potential Environmental Release facilities.

Introduction

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division, in cooperation with the Department of Energy and DOE contractors, conduct a facility survey program on the Oak Ridge Reservation. The program provides a comprehensive independent assessment of active and inactive facilities on the reservation based on their: (1) present physical condition (2) inventories of radiological materials and hazardous chemicals (3) levels of contamination; and (4) operational history. The ultimate goal of the program is to fulfill the commitments agreed to by the state of Tennessee and the Department of Energy in Section 1.2.3 of the *Tennessee Oversight Agreement* which states that "Tennessee will pursue the initiatives in attachments A, C, E, F, and G. The general intent of these action items is to continue Tennessee's: (1) environmental monitoring, oversight and environmental restoration programs; (2) emergency preparedness programs; and (3) delivery of a better understanding to the local governments and the public of past and present operations at the ORR and potential impacts on the human health and/or environment by the ORR." **The overall objective of the**

Facility Survey Program is to provide a detailed assessment of all potential hazards affecting or in any way associated with facilities on the Oak Ridge Reservation. To this end, the program evaluates facilities' potential for release of contaminants to the environment under varying environmental scenarios ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. This information is also essential for proper emergency preparedness planning.

Methods, Materials, and Evaluating the Potential for Environmental Release (PER)

Survey-program team members take a historical research approach in evaluating each facility. Prior to commencing fieldwork they examine engineering documents, past contaminant release information, hazard-screening documents, drain databases, and radiological and chemical inventory data. Then they perform a walk-through of the facility with the facility manager to gather interview information, and to "ground truth" previously reviewed documents. During the walk-through, calibrated radiation survey instruments are used to estimate radiation contamination and dose levels. At the end of the document review and walk-through process, a final report is produced, and descriptive information is entered into the division's Potential for Environmental Release (PER) database. This database helps the team portray conditions at each facility based on its physical condition and potential for release of contaminants to the environment.

The PER database contains an index of 10 "categories" that relate directly to the contents and condition of the operational infrastructure within and around each facility (Table 1). For each facility, every category is assigned a score from 0 to 5. A "5" reflects the greatest potential for release of contaminants, that a release has already occurred (legacy) or, the greatest degree of degradation of infrastructure. A "0" indicates the least potential (Table 2). As facilities are scored, totaled, and compared with each other, a relative ranking emerges. Special circumstances, such as legacy releases and professional judgment may also influence this scoring. Importantly, scores are **not intended to reflect human health risk.** Rather, their sole purpose is to characterize facilities based on the conditions in and around them. This information is used within the division for information, comparison, emergency planning, and review purposes only.

The final report notifies DOE of the division's findings so that it has the opportunity to respond and formulate corrective actions. When the division receives written confirmation from DOE of corrective actions taken on a specific facility, the ranking for that facility is modified accordingly. The 10 "categories" that are scored and the "scoring criteria" are presented below in Tables 1 and 2. Table 3 provides preliminary results.

Table 1: Categories to be scored

1.	Sanitary lines, drains, septic systems
2.	Process tanks, lines, and pumps
3.	Liquid Low-level Waste tanks, lines, sumps, and pumps
4.	Floor drains and sumps
5.	Transferable radiological contamination
6.	Transferable hazardous materials contamination
7.	Ventilation ducts and exit pathways to create outdoor air pollution
8.	Ventilation ducts and indoor air/building contamination threat
9.	Radiation exposure rates inside the facility escalated
10.	Radiation exposure rates outside the facility escalated

Table 2: Potential Environmental Release Scoring Guidelines

Score	Score is based on observations in the field and the historic and present-day threat of contaminant release to the environment/building and/or ecological receptors.
0	**No threat**: no quantities of radiological or hazardous substances present.
1	**Minimal threat**: minimal quantities present, possibility of an insignificant release, very small probability of significant release, modern maintained containment.
2	**Moderate threat**: significant quantities of radiological or hazardous subs. present, structures stable in the near to long term, structures have integrity but are not state-of-the-art, adequate maintenance.
3	**Moderate threat**: structures unstable, in disrepair, containment failure clearly dependent on time, integrity bad, maintenance lacking, containment exists for the short term only.
4	**Imminent threat**: considerable quantities of radiological or hazardous subs. present. Containment for any period of time is questionable, migration to environment has not started.
5	**Release**: radiological or hazardous substance containment definitely breached, environmental/interior pollution from structures detected, radiological and/or hazardous substances in inappropriate places like sumps/drains/floors, release in progress, or radiological exposure rates above Nuclear Regulatory Commission (NRC) guidance.
Note: A score of 0 or 1 designates a low Potential Environmental Release rank; a score of 2 or 3 designates a moderate rank; a score of 4 or 5 designates a high rank.	

Discussion and Results

The Facility Survey Program entered its eighth year in January 2001. As in previous years, inter-agency staff cooperation was very professional. The flow of information relating to corrective actions, changes in facility status or mission, decommissioning and decontamination activities, and onsite professional activities was smooth and efficient. During 2001 the survey program's Y-12 representative spent approximately one half of his time at the Y-12 field office. This presence greatly enhanced program activities at that site.

In accordance with past TDEC policy, an individual survey conducted on a leased facility at ETTP might only address those portions of the facility that are leased. Consequently, some reports may not include adjacent areas in the same facility or related facilities. Therefore, adjacent areas and related facilities may be contaminated and/or exhibit safety problems that are not reflected in the report.

Furthermore, since we are continually in the process of evaluating corrective actions at facilities, any current ranking may not reflect the most recent corrective actions. Since the inception of the FSP program, corrective actions have removed seven facilities (X-3525, X-7823-A, X-7827, K-

1098-F, X-3505, K-1200-C, X-7700) from the DOE-O list of "high" Potential Environmental Release facilities.

In 2001 the team surveyed 17 facilities: 4 at ORNL (#3026, #3592, #3504, #2531), 7 at K-25 (#1008-D, #1021, #1004-A, #1004-B, #1004-D, #723, #1021-A), and 6 at Y-12 (#9204-3, #9703-14, #9999-2, #9401-2, #9824-4, #9824-5). Eight of these facilities were ranked as having a "high" Potential for Environmental Release; four at ORNL (#3026, #3592, #3504, #2531), two at Y-12 (#9743-2, #9401-2), and two at K-25 (#1004-B, #1004-A).

Table 3: Facility Survey Program Summary

		High PER Facilities	Removed High PER	Facilities Resurveyed
A. Facilities surveyed, 1994	15	9	0	0
B. Facilities surveyed, 1995	35	11	0	0
C. Facilities surveyed, 1996	34	9	0	0
D. Facilities surveyed, 1997	23	8	0	0
E. Facilities surveyed, 1998	8	2	1	2
F. Facilities surveyed, 1999	14	1	0	0
G. Facilities surveyed, 2000	14	4	3	0
H. Facilities surveyed, 2001	17	8	3	1
I. Totals	160	**45**	**7**	**2**

Description of the 48 Highest Scoring Facilities (1994-01)

The total score of the 10 categories is not always the best indicator of conditions at a facility and its potential for environmental release. Rather, what appears to be the most accurate indicator is the number of categories for which a facility scores a four or five (Table 1). Of the 160 facilities scored since 1994, 48 stood-out with one or more categories scoring a four or five (Table 4). The following high-scoring facilities are arranged in descending order of total numbers of fours and fives in the PER database. Facilities X-3505 and X-7819 were demolished in 2001; X-7819 is still ranked in this database because of legacy contamination on the landscape

Table 4: Potential for Environmental Release for 48 High Scoring Facilities

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
	DRAIN	TANKS	TANKS	SUMPS	TRANSF	TRANSF	VENT TO	VENT	INT. EXP.	O. EXP.	NUMBER	SURVEY
	LINES	LINES	LINES	DRAINS	RAD.	HAZ.	OUTSIDE	INSIDE	RAD.	RAD.	OF	YEAR
BUILDING	SANI.	PROC.	LLLW	FLOOR	CONT.	CONT.	AIR	SYSTEM	SURVEY	SURVEY	4 and 5's	
X3028	0	4	4	3	4	4	4	5	5	3	7	1997
*****X3505	0	0	0	0	0	0	0	0	0	0	0	2000
K1037-C	0	0	0	0	5	5	5	5	5	4	6	1998
K1025-A	0	0	0	4	4	4	4	3	4	4	6	1995
Y9401-2	1	4	1	4	1	5	4	4	1	0	5	2001
Y9204-3	3	5	2	3	4	5	4	4	2	1	5	2000
X3019-B	2	2	5	3	2	3	4	4	4	4	5	1995
K1004-B	5	0	0	5	2	5	2	5	2	0	4	2001
K1004-A	5	0	0	5	2	5	2	5	2	0	4	2001
*X7819	0	0	4.5	0	3	0	0	0	0	5	2	1994
X7700	3	0	0	3	0	0	2	2	3	0	0	1996
X7700C	4	4	0	4	2	1	2	0	0	4	4	1996
Y9201-4	2	5	0	2	2	4	5	5	2	1	4	1998
K1004-J	5	5	0	4	3	0	0	0	1	1	3	2000
Y9203	4	2	0	4	2	4	2	2	2	0.5	3	1995
X2545	0	3	5	0	4	2	3	0	0	4	3	1995
K1200-C	1	3	0	1	3	1	2	0	1	3	0	1995
Y9769	1	1	0	4	4	2	1	2	4	2	3	1995
K1025B	0	0	0	2	5	2.5	3	2	4	5	3	1996
X3020	0	0	5	5	5	0	2	0	0	1	3	1997
X3108	0	0	5	5	5	0	2	2	2	2	3	1997
X3091	0	0	5	5	5	1	2	2	3	2	3	1997
Y9743-2	0	3	0	5	3	5	2	2	2	1	2	2001
X3592	0	3	3	2	4	4	3	3	3	2	2	2001
X3504	1	3	0	4	5	0	2	1	2	2	2	2001
X2531	1	1	2	1	5	2	2	1	2	4	2	2001
Y9213	3	1	5	3	3	5	1	1	1	1	2	2000
Y9404-3	1	5	0	5	0	3	0	0	0	0	2	1994
X7720	0	0	0	0	4	0	0	0	0	4	2	1996
X3001	3	1	2	3	3	2	4	4	3	3	2	1995
Y9208	2	0	0	2	1	4	4	2	1	1	2	1995
K1200S	2	3	0	3	3	2	3	4	2.5	4	2	1995
X7701	4	3	0	4	2	0	2	0	0	3	2	1996
X7706	4	3	0	4	2	0	2	2	2	2	2	1996
X7707	4	0	0	4	2	3	2	2	0	0	2	1996
X3085	1	4	3	3	3	2	1	2	3	3	1	1994
X7602	0	2	0	2	4	2	1	3	2	1	1	1997
Y9620-2	0	4	0	1	0	2	2	2	0	0	1	1994
K1220N	0	2	0	0	3	2	2	4	2	3	1	1995
X3002	0	2	0	2	3	1	2	3	4	1	1	1996
Y9210	1	0	0	4	1	1	1	2	1	0	1	1995

Y9224	1	0	0	4	1	1	1	2	1	0	1	1995
Y9211	1	0	0	4	1	1	1	2	1	0	1	1995
Y9207	2	0	0	1	1	4	3	1	1	0	1	1995
X7055	0	0	0	4	0	1	1	1	0	0	1	1997
X7700B	0	0	0	0	3	0	2	0	0	4	1	1996
K1401L3	1	0	0	1	4	2	1	2	3	1	1	1997
Y9201-3	2	1	0	2	3	5	2	2	2	1	1	1999

*Denotes a demolished facility

At **Y-12** fifteen facilities had at least one category score of 4 or 5: 9204-3, 9201-4, 9401-2, 9213, 9743-2, 9203, 9769, 9404-3, 9208, 9620-2, 9210, 9224, 9211, 9207, and 9201-3.

Facility Y-9204-3 (Beta 3) is one of the original isotope enrichment facilities at Y-12. It received two category scores of 5, three category scores of 4, and a total score of 33. This 250,000sq. ft. facility is now inactive and locked. The largest issues are leaking PCB-contaminated mineral oil (Z-oil), and radiological contamination. The building has not been sampled above eight feet for radiological contamination, even though the probability of finding it is great. The interior ventilation system exhausts directly to the environment without HEPA filtration.

Facility Y-9201-4 (Alpha 4) is also one of the original Y-12 uranium enrichment buildings. It received three category scores of 5, one category score of 4, and a total of 28. Mercury, mercury vapor, lithium hydroxide, PCBs, asbestos, and lead/chromium based paint are the contaminants of concern in this facility. Mercury is found throughout the process system. The containment integrity of this system is low and has resulted in breaches that have deposited mercury in unwanted places throughout the building. Evidence suggests that open (non-filtered) exhaust fans have distributed mercury vapor from the interior of the building to the environment for decades. Lithium hydroxide, PCBs, asbestos insulation, and chipping/flaking lead-based paint are also found deposited throughout the building.

Facility Y-9401-2 (Plating Shop) received four category scores of 4, one category score of 5, and a total of 25. All of these scores relate to a variety of chemical contamination issues.

Facility Y-9213 (Criticality Experiment Facility) received two category scores of 5, and a total of 24. This facility was built in 1951 and contains two underground neutralization tanks and an underground pit. The tanks and pit present a very high potential for radiological and chemical soil contamination. The areas around the tanks have not been sampled for contamination. The facility also exhibits extensive flaking of exterior lead-based paint.

Facility Y-9743-2 (Animal Quarters) received two category scores of 5, and a total of 20. These scores were given because of the total lack of institutional and process knowledge, and the lack of radiological and chemical sampling surveys. There are interior tanks and bottles with unknown contents. There is a total lack of maintenance. There is a high possibility of biological and chemical contamination.

Facility Y-9203 (Instrumentation, Characterization Department and Manufacturing Technology Development Center) has three category scores of 4 and a total score of 22.5. The primary

problem in this facility is the drain system. Despite much work that has been done to reroute process drains from terminating in the storm sewer system, these drains now go to the sanitary sewer system. This termination still presents a potential pathway to the environment and the public.

Facility Y-9769 (Analytical Services Organization) has three category scores of 4 and a total score of 21. The primary hazards associated with this facility are related to the wide variety of toxic materials maintained in the laboratory and the building's drain destination. Exit drains go to the Oak Ridge Sewage Treatment Facility and therefore represent a pathway for contaminants to the city's effluent and/or sludge. Also, the sub-basement area is posted as a contamination area and confined space. This area has legacy contamination of natural uranium. Depending on the quantity of natural uranium, a significant source term for radium-226 and radon-222 exists. Failure of containment could cause a release to East Fork Poplar Creek or to the atmosphere.

Facility Y-9201-3 (Alpha 3) received one category score of 5, and a total of 20. This facility is not receiving any maintenance on its exterior painted surface. Lead based paint is chipping and is being spread extensively around the building.

Facility Y-9404-3 (Z-oil pumphouse) at Y-12 has two category scores of 5 and a total score of 14. The primary hazard is PCB contaminated oil in sumps and pumps and old oil lines beneath the floor. PCBs are carcinogenic, and have a high bioaccumulation factor. Without secondary containment, very small leaks may allow PCBs to enter the food chain via fish and other wildlife.

Facility Y-9208 has two category scores of 4 and a total of 17. Despite administrative controls that were implemented, the asbestos-bearing paint peeling from the outer walls still presents an airborne particulate problem if not mitigated with an engineering control.

Facility Y-9620-2 (Oil Filtration Facility) had one category score of 4 and a total score of 11. The primary concerns with this facility are PCB contaminated filter presses and transfer oil dryers that still contain PCB-laden Z-oil without secondary containment. PCB contaminated oil is also on the floor. A secondary concern is that the roof is not maintained and may not support a person's weight.

Facilities Y-9210, Y-9211,Y-9224 (ORNL Biology) each had one category score of 4 with a total score of 11 for each facility. The original concern regarding each of these facilities was the questionable terminal destinations of their exit drains. Written confirmation from the DOE contractor has since shown the correct terminations and corrective actions taken on some of these drains. However, there are still undefined and/or inappropriate drain terminations (i.e. lab drains that terminate at the sanitary sewer).

Facility Y-9207 (Biology Complex) received one category score of 4, and a total score of 13. In this facility the sinks in a radiological area drain directly to the Oak Ridge sewer system, and thus represent a potential pathway for radiological materials to the city sewage and sludge.

At **ETTP** ten facilities had at least one category score of four or five: K-1037-C, K-1004-B, K-1004-A, K-1025A, K-1025B, K-1200-C, K-1200-S, K-1004-J, K-1220-N, and K-1401L3.

Facility K-1037-C (Nickel Smelter House) received five category scores of 5, one category score of 4, and a total of 29. This is an old facility with numerous roof leaks and in general disrepair. The building is heavily contaminated, both radiologically and chemically. Large scrubber-type vessels located on the east-end of the second floor of the barrier production area contain internal radioactive contamination. Discarded contaminated equipment is stored in the building. The facility is posted as a PCB hazard. No corrective actions have been completed at this facility (2001).

Facility K-1004-B (Analytical Chemistry Lab.) received four category scores of 5, and a total of 26. These scores were given for radiological contamination in the ventilation system, and chemical contamination in the drains. No corrective actions have been completed at this facility (2001).

Facility K-1004-A (Analytical Chemistry Lab.) received four category scores of 5, and a total score of 26. These scores were given primarily for chemical contamination in the drain and ventilation systems.

Facility K-1025-A (Radiological Source Control Building) received six category scores of 4, and a total score of 27. The entire building is a contamination zone with plugged floor drains. The building houses radiological sources, and there is evidence that water has been standing in the building. The integrity of the roof is suspect. Floor drains historically went into a French-drain system with an unknown termination point. Elevated radiological readings outside of the building indicate that drains exit into the yard, and that contamination has moved into the environment. No corrective actions have been taken on this facility (2001).

Facility K-1200-C (Centrifuge Preparation Laboratory, Center Bay) at K-25 has one category score of 5, two scores of 4 and a total score of 26. The primary hazard is PCB-contamination. Inactive equipment in the facility contains PCBs and there is a designated PCB spill area associated with under-floor drain lines. Radiological contamination is another concern. Several Radiological Contamination Areas are posted in the facility. The interior ventilation ductwork and portions of the roof have not been surveyed for radiological contamination. These circumstances present a degree of uncertainty that is reflected in the score. Several corrective actions were completed at this facility during 2001. The PCB-contaminated equipment was removed. The PCB-contaminated floor was decontaminated. All radiologically contaminated ventilation ductwork was removed. All radiological contamination was cleaned. The facility was down-posted. The facility was removed from the division's "high ranking" facilities list (2001).

Facility K-1025-B (Drum Storage Warehouse) has one category score of 4, two category scores of 5, and a total of 23.5. The primary concern associated with this facility is radiological contamination. Radiological contamination has moved from within the building via the floor drain system and has contaminated the soil in front of the building. Since a radiological survey

map was not available to TDEC, the magnitude of soil contamination is unknown. The division has not been notified of actions taken to address these issues.

Facility K-1200-S (Centrifuge Preparation Laboratory, South Bay) at K-25 has two category scores of 4 and a total score of 26.5. The high score is primarily attributable to the uncertainty of radiological contamination associated with the ventilation system. The interior ductwork and portions of the roof where air is exhausted have not been surveyed for contamination. The potential for airborne release there appears great. Equipment inside the facility contains uranium hexafluoride and other hazardous chemicals, and there are numerous radiologically contaminated storage areas. Confined space entry requirements prevented the division from performing a survey of the pits below the centrifuges. The greatest release potential for contaminants would be during decontamination and decommissioning activities. Equipment removal and clean up is ongoing at this facility. It is expected that the facility will in the future be removed from the DOE-O "high rankers" list (2001).

Facility K-1004-J received two category scores of 5, one category score of 4, and a total of 19. This facility was constructed in 1948 and was originally used for uranium recovery from spent fuel solutions, and centrifuge research. It originally included a hot cell, reinforced concrete vaults, and a 750 gal. "hot" tank, a 5,500 gal. underground Low Level Liquid Waste tank, and a laboratory. The facility was ranked high in the PER database because of a poor state of knowledge concerning facility infrastructure. First, there is considerable uncertainty over the location and number of active storage vaults under the facility. It is also unknown whether any of these vaults contain radioactive materials or contamination. There is also considerable uncertainty over drainpipe connections and their contribution of radiological and chemical contaminants to general area contamination. No corrective actions have been completed at this facility (2001).

Facility K-1220-N (Centrifuge Plant Demonstration Facility, North) at K-25 has one category score of 4 and a total score of 18. The interior ductwork has not been surveyed for radiological contamination and the score reflects a high degree of uncertainty concerning the presence of radionuclides. Uranium residuals are present inside the centrifuge systems. After the centrifuge systems are removed and the criticality and security concerns are addressed, this facility is a candidate for reuse. No corrective actions have been conducted at this facility (2001).

Facility K-1401L3 received one category score of 4, and a total score of 15. This ranking was given because of extensive radiological contamination, which encompasses the building and housed equipment. There are also suspect contaminated areas that have not been surveyed, such as the areas above 8 feet.

At **ORNL** twenty three facilities had at least one category score of four or five: X-3028, X-3505, X-3019-B, X-7819, X-3001, X-7700, X-7700C, X-7701, X-7706, X-7707, X-7720, X-7700B, X-2545, X-3504, X-2531, X-3592, X-3002, X-3020, X-3108, X-3091, X-3085, X-7602, and X-7055.

Facility X-3028 received two category scores of five, five category scores of 4, and a total score of 36. The primary issue with this facility was the relatively large source term of radiological contamination distributed throughout the building. It also shows extensive peeling and chipping of interior wall paint that is supposed to serve as containment for plutonium contamination. Ongoing corrective actions are occurring at this facility.

Facility X-3505 (Metal Recovery Facility) originally received five category scores of 4, two category scores of 5, and a total of 35. This was a highly contaminated facility that was demolished the last quarter of 2001. The canal and dissolver pit have been cleaned of sludge (TRU waste) and have been grouted in. The concrete floors of the hot cells were grouted over to reduce dose rates and to prevent migration of radiological contamination. The whole footprint of the bldg. has been covered with one millimeter of epoxy. The epoxy has been covered with packed crusher run gravel. The site will be left in that configuration. Scores have been modified and the bldg. has been dropped from the list of "high ranking" facilities.

Facility X-3019-B (High Level Radiation Analytical Laboratory) at ORNL has four category scores of 4, one category score of 5, and a total score of 33. The primary concern with this facility is the very high level of radiological contamination. The eight hot cells in this facility are "Very High Radiation Areas" and contain many different radionuclides from past operations. The in-cell steam pipes, the off-gas ventilation system, and the ventilation ductwork on the roof are also radiologically contaminated. Also, the Laboratory Off-Gas ductwork located above the hot cells contains perchlorates six times above the maximum recommended by the ORNL Perchloric Acid Committee Corrective. Perchlorates are shock sensitive and have the potential to react violently when disturbed. Signage identifying this hazard is posted, and the situation was recently upgraded from an "Off-normal" to an "Unusual Occurrence."

Facility X-7819 (Old Decontamination Facility) originally had 3 category scores of 5, one category score of 4.5, and a total score of 35.5. Corrective actions reduced this score to 30.5. In 2001 the facility was demolished in 2001, and scores were adjusted to a total of 12.5. The remaining scores relate to legacy soil contamination that is still on the site. The facility will continue to be scored as a "high ranker" until the soil contamination is removed or rendered immobile. Several radionuclides are involved.

Facility X-3001 (Graphite Reactor) at ORNL has two category scores of 4, and a total score of 28. The primary concern with this facility is that there is considerable radiological contamination. The air exhaust shaft that vented the reactor pile is contaminated with cesium-137, strontium-90, and fission products. This is a source releasable to the outside environment if a fire or other event occurred in the ventilation system. Several corrective actions, such as the plugging of drains that went to the sewer system, were recently addressed at this facility.

Facilities X-7700, 7700C, 7701, 7706, 7707, 7720, 7700B (Towers, scrapyard, above-ground storage areas, waste storage tank, reactor pool, heat exchanger bldg., battery house, civil defense bunker, below-ground outside source storage area) are all part of the Tower Shielding Complex. A survey of this group of facilities resulted in two category scores of 5, and 14 category scores of 4. The primary issues at this complex of facilities are: soil contamination, uncovered activated

and contaminated equipment and material, and drain lines that have direct connections to the environment. Corrective actions have resolved most issues at this facility. The scrap-yard has been completely cleaned, and has been removed from the high-ranking facilities list (#7700). All contaminated and activated materials have been removed from the tower area (#7700). The only major issues left at this facility are the activated concrete that is sitting out in the weather at the bunker (#7720), and the fact that many of the drains terminate at a septic tank.. Scores have been adjusted accordingly, and #7700 has been removed from the high-ranking facilities list in 2001.

Facility X-2545 (Coal Yard Runoff Collection Basins) at ORNL has one category score of 5, two category scores of 4, and a total score of 21. Orphaned, 2- and 6-inch diameter, cast iron Low Level Liquid Waste (LLLW) lines run through the facility property, and a LLLW line box is posted as a radiation area. The area has been chained off and is overgrown with vegetation. Due to the radiological postings, the cast iron LLLW lines are assumed to be degraded and leaking to the environment. ORNL Environmental Restoration staff has been notified of these lines and their condition, but TDEC has not received written confirmation concerning corrective actions.

Facility X-3504 (Geosciences Lab.) received one category score of 5, one score of 4, and a total of 20. The entire building is a posted contamination area. During the survey a new contamination area was discovered outside of the facility. The ORNL health physics dept. designated the area a new radiological zone. There is also underground contamination on the West Side of the building.

Facility X-2531 (Radiological Waste Evaporator Facility) received one category score of 5, one score of 4, and a total 21. This ranking includes #2537 (Evaporator Pit) and #2568 (HEPA filter bldg.). Even though this is a relatively clean, modern facility, it earned these scores because of several areas of transferable radiological contamination, and high radiation dose rates surrounding the outside evaporator pit.

Facility X-3592 (Coal Conversion Facility) received two category scores of 4, and a total of 27. Its original mission was to explore the potential for utilizing liquefied coal as an alternative fuel source. But in later years the facility performed lithium isotope separation using massive quantities of mercury. The scores were given for transferable radiological contamination, and mercury contamination in the drains.

Facility X-3002 (HEPA Filter House for the Graphite Reactor) has one category score of 4, and a total score of 18. The primary hazards associated with this building are related to the high level of airborne and other radiological contamination in the roughing filter room, the HEPA filter bank, and the ventilation system. Several corrective actions that were recommended by the division were implemented at this facility.

Facility X-3020 (Radiological Stack for bldg. 3019A-B) received three category scores of 5, and a total score of 18. All of the major concerns noted for this facility were related to legacy features that are not part of the present-day operational infrastructure, but are still present on the site. First, there is an antiquated, contaminated drain line that was part of the ORNL LLLW system. This line leaked and contributed to surface and subsurface contamination of the general area from

the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing contamination. There is also a contaminated, above-grade, single-walled concrete sump box attached to the floor drain system. The need for a comprehensive stack inspection was noted in the 1997 Facility Survey Program Annual Report. An inspection was conducted in 1998 and, found the stack to be in "sound condition."

Facilities X-3108 and 3091 (HEPA filter houses for buildings 3019A-B and Radiological Stack 3020) each received three category scores of 5. 3108 received a total score of 23, and 3091 received a total score of 25. These two facilities are physically connected to the 3020 stack. And like the 3020 Stack situation described above, all major concerns noted with these facilities are related to their non-operational infrastructure. Associated with both facilities is a contaminated drain system that went to the LLLW system. This line leaked and contributed to surface and subsurface contamination of the general area from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing to contamination. Both facilities also contain significant levels of radiological contamination, considerable contaminated aboveground ductwork, and contaminated lower-level HEPA filter pits. Both facilities are non-state-of-the-art structures that are adequately maintained.

Facility X-3085 (Oak Ridge Research Reactor Pumphouse) received one category score of 4, and a total score of 25. This score was based on the possibility for underground leakage of contaminated water from the 10,000 gallon decay tank, and from the underground valve sump tank located in the front of the building. Two empty but internally contaminated, aboveground tanks are still tied to underground piping adjacent to the building. Several recommended corrective actions, such as the plugging of floor drains have been completed at this facility.

Facility X-7602 (Integrated Process Development Lab.) received one category score of 4, and a total score of 17. Extensive cleanup and decontamination occurred at this facility in 2001. However, the high bay area still contains quantities of radiologically contaminated equipment and infrastructure.

Facility X-7055 (Storage Bldg.) scored one category score of 4, and a total score of 7. The only concern with this building was that it has a floor drain system that is connected directly to the outside yard. Even though the building has changed missions and several corrective actions have been implemented, it still contains hazardous materials.

Conclusion

The historic release of chemical and radiological materials from buildings and other facilities on the Department of Energy's Oak Ridge Reservation has led to elevated levels of these contaminants in the regional environment. In an effort to better understand the sources of these contaminants, the Tennessee Department of Environment and Conservation's DOE-Oversight Division investigates the historic and present-day potential for release of contaminants from facilities through its Facility Survey Program. During its seven-year history the program has examined 160 facilities and found that about thirty percent (48) still pose a relatively high potential for release of contaminants to the environment. In many cases legacy contamination from degraded facility infrastructure, such as underground waste lines, or substandard sumps and

tanks, or ventilation ductwork, will drive high scores until facilities are fully remediated. This is particularly the case at Oak Ridge National Laboratory where many facilities were connected to an aging low-level liquid waste line system. Many inactive facilities are no longer receiving adequate maintenance due to a lack of funding. On many sites, peeling lead-based paint is extensive, and will only get worse as time passes if not remediated. This condition is also driving high scores.

When facility concerns are noted by the DOE-O Division, they are relayed to the Department of Energy via the Facility Survey Report so that corrective actions can be formulated. To date, many corrective actions have occurred, and seven facilities have been removed from the division's list of high Potential Environmental Release facilities. Those concerns that have not been corrected to the extent that the division has reduced the PER ranking to less than a "4" are reflected in this report. The rankings are changed when documentation from DOE is received by the division. Since the evaluation of corrective actions is an ongoing time-consuming process, present scores may in some cases not reflect the most recent completed corrective actions.

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Chapter 7 RADIOLOGICAL MONITORING

Ambient Gamma Radiation Monitoring of Poplar Creek From its Confluence With the Clinch River Upstream to the Mouth of East Fork Poplar Creek

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Abstract

Due to the current reindustrialization of ETTP (formerly K-25), a walkover survey was instituted along Poplar Creek from its confluence with the Clinch River upstream to the mouth of East Fork Poplar Creek. The main purpose of this study was to identify the areas where Poplar Creek and its respective floodplain on the Oak Ridge Reservation may have become contaminated by deposition of radionuclides in channel sediments.

The walkover shoreline survey was performed between January and April 2001, with a follow-up boat survey performed in October 2001. The purpose of the survey was to perform a radiological screening of the sediments using a sodium iodide detector. Major sites of concern were the channel course and floodplain of Poplar Creek between its confluence with the Clinch River and upstream, to the mouth of East Fork Poplar Creek. During the walkovers, TDEC was observant of any suspicious or potential dumpsites, hazardous substances or containers such as 55-gallon drums.

Essentially, no new discoveries of radioactively contaminated sites were found during the course of the TDEC land and boat surveys of Poplar Creek. The gamma shine, from the UF-6 cylinder yards, was known prior to the commencement of fieldwork. The highest gamma reading detected with the sodium iodide instrument was 130,000 + counts per minute (cpm) at the fence of UF-6 cylinder yard # K-1066-E (near TDEC field station "POP37"). The lowest reading of 4730 cpm was at TDEC station "POP79" in the area near the shoreline, adjacent to Perimeter Road and the bend of Poplar Creek. There was one exposed beach site ("POP62"), where gamma readings were above twice background (+23,000 cpm). This reading was attributed to underlying geological conditions rather than UF-6 gamma shine. A baseline of 9,000 cpm was established for this project.

Introduction

The Tennessee Oversight Agreement (TOA) has established an integral working relationship between the Tennessee Department of Environment & Conservation (TDEC) and the Department of Energy. This relationship assures the citizens of the state of Tennessee that human health and the environment are protected during the course of ongoing monitoring of environmental media, cleanup activities and emergency response efforts on the Oak Ridge Reservation and surrounding areas. Attachment C (Tennessee Action Items) – indicates "The state will conduct a monitoring program at the Oak Ridge Reservation and surrounding areas for radiological oversight."

The main purpose of this study was to identify the ecological pathways and impacted areas where Poplar Creek, and its respective floodplain on the Oak Ridge Reservation, may have become contaminated by deposition of radionuclides in channel sediments. The project was

instituted due to the current reindustrialization of ETTP (formerly K-25) and potential health concerns the state had with this area on the Reservation.

The walkover shoreline survey was performed between January and April 2001, with a follow-up boat survey performed in October 2001. The objective of the survey was to perform a radiological screening of the sediments and measure the tissue equivalent dose rate. The majority of the combined survey was performed at near full pool lake stage conditions, thus potentially available low pool sediments were inundated and shielded by river/creek water. Major sites of concern were the channel course and floodplain of Poplar Creek between its confluence with the Clinch River and upstream to the mouth of East Fork Poplar Creek. During walkovers, TDEC was observant of any suspicious or potential dumpsites, hazardous substances or containers such as 55-gallon drums.

Methods & Materials

Procedures employed during this project are consistent with those contained in the *TDEC/DOE-O Work Plan for the Walkover Survey Program* for the field surveys, specifically for radiation monitoring in the field environment. The field team consisted of Robert Storms and Gerry Middleton. The team used a Ludlum Model 2221 Scaler Ratemeter with a 2x2-inch Sodium Iodide (NaI) detector. Continuous monitoring was adhered to during the entire survey. Three 1-minute counts were performed at each survey point for coverage purposes and areas of concern.

TDEC employed a foot-survey while conducting field reconnaissance activities for coverage of the Poplar Creek watershed. The TDEC survey covered approximately 6.0 creek miles between the confluence of Poplar Creek/East Fork Poplar Creek and Poplar Creek/Clinch River. This field coverage method involved walking through the terrain of the watershed through adjacent woods, open fields, ridges, and exposed sediments in and adjacent to the shoreline. Staff utilized map and compass reading techniques in addition to global positioning system (GPS) technology. Both banks of Poplar Creek were walked and a follow-up boat survey was carried out as well. The majority of the time during the survey, the Clinch River lake stage was at or near full pool limiting access to creek sediments not shielded by creek water. The sodium iodide gamma detector was carried in the field at all times and readings were recorded at prescribed survey points.

The K-25 Gaseous Diffusion Plant enriched uranium using uranium hexafluoride (UF-6). Consequently, the main radionuclides of concern were uranium (U-235 and U-238) and its daughter or fission products that produce gamma emissions. Radiological findings were recorded in counts per minute (cpm). It should be noted that if radiological contamination is detected, TDEC has a micro-rem meter instrument that provides data in tissue dose equivalent units (rem). TDEC also has a portable gamma spectrometer to determine isotopes involved with above background readings, radiologically contaminated sites, or discrepancies in the field.

A baseline for radiological counts was established with the use of several thousand readings taken on the ORR, away from the main plant areas. These numbers were calculated from data accumulated during the Footprint Reduction survey of approximately 25,000 acres. These numbers are based on the field instrument responses (sodium iodide) used for the survey as well. A baseline of approximately 9,000 cpm was established. An arbitrary threshold value of twice

local background was instituted. Readings above twice background would be noted as anomalous, with the potential for contamination.

Some uncertainty exists when trying to determine a background level that relates to survey locations. This is due to geologic conditions, topography of the immediate survey area, and soil characteristics. Local geological conditions affecting background readings include natural uranium emissions from the Rome Formation and the Chattanooga Shale. The Rome Formation is a ridge-former in our area and gamma readings as high as 25,000 cpm (NaI) have been noted at locations underlain by this rock unit. Exposures of Chattanooga Shale in the ORR area are sparse but yield gamma readings as high as 45,000 cpm. All these factors must be taken into consideration when evaluating data points in the field. Also, since some of the survey areas are developed (industrial) and the background areas are not, it is difficult to compare the two except in very general terms.

Several areas were affected by "gamma shine" from radiological materials in the environment, primarily from the UF-6 Cylinder Yards. "Shine" is the detectable radioactive emissions that can be distinguished a distance from the actual source. Typically, the larger (more mass) the amount of the source material, the greater the geographic areas of elevated gamma readings produced by shine. An example of this phenomenon would be the Duratek facility on Bear Creek Road. Gamma shine has been detected in front of the facility (while driving by on Bear Creek Road) in excess of 200,000 cpm from Co-60 sources in B-25 boxes located within the facility grounds. High gamma shine numbers are also easily detected in the vicinity of the HFIR facility, the Melton Valley Storage Tanks at ORNL, and the previously mentioned UF-6 Cylinder Yards at ETTP.

The TDEC field investigation team used a combination of map reading and Global Positioning Systems (GPS) navigation techniques and previously mentioned radiological instruments to evaluate particular points within the study area. TDEC selected field routes that would ensure maximum coverage of the area. All locations and survey points therein were identified using global positioning system (GPS) technology and later transferred to a map (see Figure 2). The map was created using MapInfo software and processed data downloaded from the GPS field unit (Trimble Navigation unit). Precision of the survey points is within 10 meters, based upon limitations of the GPS.

Impacted Areas of the Oak Ridge Reservation – Radionuclides of Concern

Figures 1 through 3 illustrate some of the main impacted areas of the Oak Ridge Reservation relating to Poplar Creek watershed. Impacted areas at ETTP that could be pathways to Poplar Creek and its tributaries include:

1. K-1070 C/D, Mitchell Branch
2. K-1407 B/C Ponds
3. K-1070-A Burial Ground
4. K-901 Pond
5. K-1407 C/D area
6. Two UF-6 Cylinder Yards:
   (a) K-1066-L (northeast of the K-25 building about 500 feet south of Poplar Creek)
   (b) K-1066-E (northwest of the K-27 building near West Perimeter Road bridge)

Results and Discussion

TDEC identified numerous locations along the course of Poplar Creek where gamma shine from the UF-6 cylinder yards ranged from 19,000-40,000 cpm.

TDEC located the "Inactive Waste Site – K-1131 Neutral Pile" ("POP116") where slightly elevated gamma readings of 16,000-17,000 cpm were recorded. The facility is located in a floodplain area down-slope of building K-631 and is adjacent to a bridge.

TDEC located two radiologically contaminated sites in the vicinity of some high bluffs west of the K-25 building and north of the K-27/K-29 buildings. One site was placarded and roped (yellow/magenta) as a "Contamination Area" (TDEC field station "POP112"). The other site, containing scrap in a ravine, was placarded and roped (yellow/magenta) as "Danger – High Contamination Area – Soil Contamination" (TDEC field station "POP113"). Sodium iodide instrument readings averaged 15,000 cpm at the rad-rope around the perimeter of the site. This site might qualify for follow-up because of the nature of the dispersal of the contaminated materials strewn about the steep ravine/drainage that dropped steeply to Poplar Creek.

TDEC located 10 aligned manholes near station "POP65" which are associated with the underwater ductwork for the K-25 Plant.

TDEC confirmed the presence of a large blue heron rookery near field station "POP 88" on Duct Island near the large bend of Poplar Creek.

TDEC located several abandoned, empty drums (55-gallon size) at several locations, abandoned scrap metal and a large metal vessel along the shoreline near Blair Quarry, and one asphalt/concrete rubble pile near the McKinney Road bridge near its junction with East Fork Road ("POP2"). Buried scrap metal and concrete including what appears to be asbestos siding was found partially exposed by erosion along the shoreline at TDEC field station ("POP51").

TDEC located a "Contamination Area" rad-roped area on a very steep embankment with a large quantity of scrap metal strewn about the slope ("POP31"). Radiological readings with the Sodium Iodide instrument ranged from 8,000-11,000 cpm.

TDEC located numerous storm drain out-falls during the course of the survey and several USGS hydrologic gauging stations (see Table I – Field Reconnaissance Data).

Conclusions

Essentially, no new discoveries of radioactively contaminated sites were found during the course of the TDEC land and boat surveys of Poplar Creek. The gamma shine, from the UF-6 cylinder yards, was known prior to the commencement of fieldwork. The highest gamma reading detected with the sodium iodide instrument was 130,000 + cpm at the fence of UF-6 cylinder yard # K-1066-E (near TDEC field station "POP37"). The lowest reading of 4730 cpm was at TDEC station "POP79" near the shoreline in the bend of Poplar Creek adjacent to Perimeter Road. There was one exposed beach site ("POP62"), where gamma readings were above twice background (+23,000 cpm). This was attributed to underlying geological conditions rather than UF-6 gamma shine.

As previously noted, abandoned scrap metal piles, drums, and some yellow/magenta roped-off "Contamination Area" sites were re-identified and located. One site was placarded and roped (yellow/magenta) as a "Contamination Area" (TDEC field station "POP112"). The other site containing scrap in a ravine was placarded and roped (yellow/magenta) as "Danger – High Contamination Area – Soil Contamination" (TDEC field station "POP113"). Sodium iodide instrument readings averaged 15,000 cpm at the rad-rope around the perimeter of the site. This site might qualify for follow-up field reconnaissance because of the nature of the dispersal of the contaminated materials strewn about the steep ravine/drainage, which drops steeply to Poplar Creek creating a possible pathway for contaminant migration.

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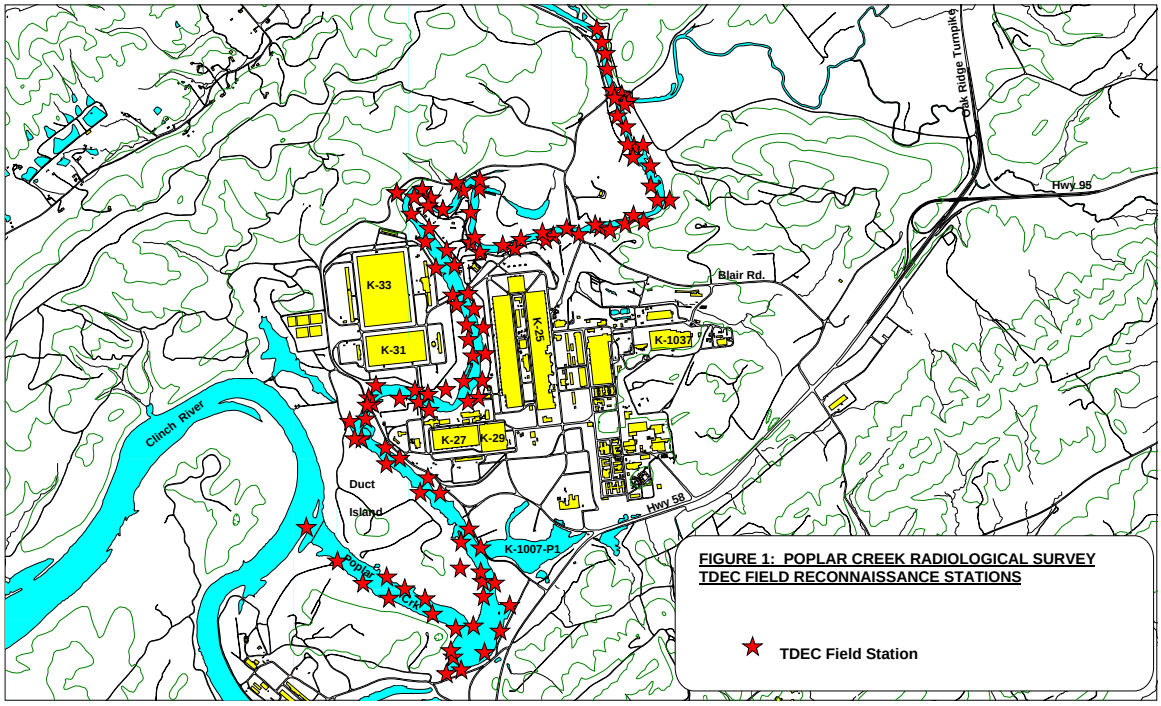
FIGURES



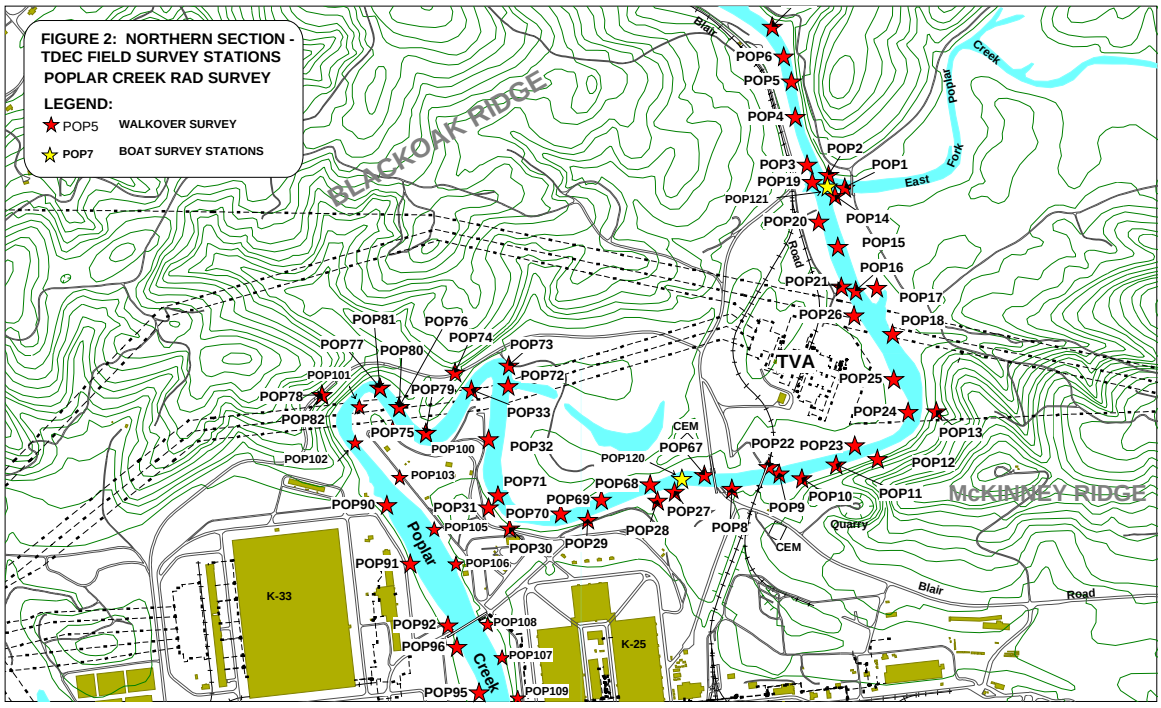


FIGURE 2: NORTHERN SECTION - TDEC FIELD SURVEY STATIONS
POPLAR CREEK RAD SURVEY
LEGEND:
POP5 WALKOVER SURVEY
POP7 BOAT SURVEY STATIONS
BLACKOAK RIDGE
McKINNEY RIDGE
TVA
K-33
K-25
Poplar Creek
Poplar Creek East Fork
Blair Road
CEM
Quarry

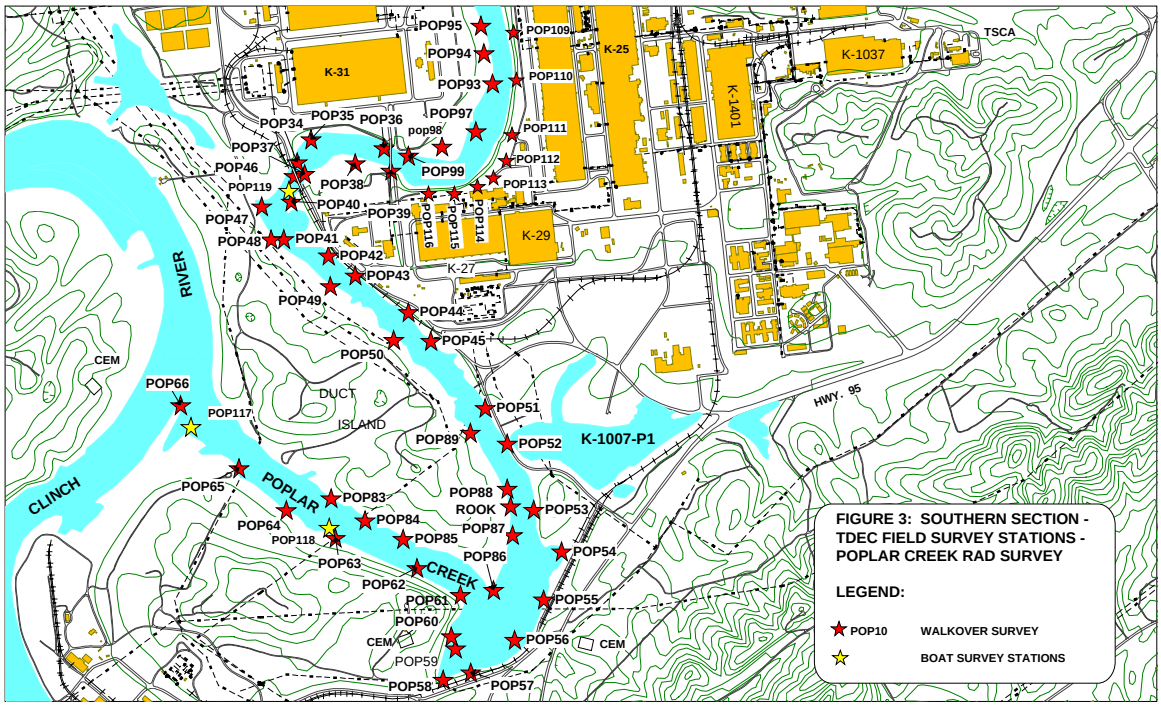


FIGURE 3: SOUTHERN SECTION - TDEC FIELD SURVEY STATIONS - POPLAR CREEK RAD SURVEY
LEGEND:
POP10 WALKOVER SURVEY
BOAT SURVEY STATIONS
K-31
K-25
K-1037
K-1401
K-29
K-27
TSCA
CLINCH RIVER
POPLAR CREEK
K-1007-P1
DUCT ISLAND
ROOK
HWY. 95
CEM

Chapter 7 RADIOLOGICAL MONITORING

Follow-up on Environmental Restoration Footprint Reduction Maintenance Actions on the Oak Ridge Reservation

Principal Authors: Gerry Middleton, Robert Storms

Abstract

The Oak Ridge Reservation (ORR) was placed on the National Priorities List (NPL) in 1989. The purpose of Footprint Reduction was to identify portions of the ORR that have not been environmentally impacted by past federal (Department of Energy – DOE) activities. The mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations.

The goal was further identified as reducing the size and configuration of the area of the ORR designated as part of the NPL site and determining a No Further Investigation (NFI) status. The land parcels were assigned numerical identifiers ranging from 1 through 20.

Tennessee Department of Environment and Conservation - Department of Energy Oversight Division (hereinafter, "the division", or "division") performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and exit pathway releases on the ORR that could render the parcel(s) unfit for release. In summation, the division investigated 21,439 acres of ORR land during the footprint project.

In performance of the field investigation work, certain maintenance action items were identified on the various land parcels, i.e., "study areas" (see Appendix I). The division clearly emphasized these concerns to DOE in each footprint study area report released to the public. This current project revisited these sites to determine if action had in fact been taken by DOE to rectify the problems and other division concerns.

Introduction and Scope

The ORR was placed on the National Priorities List (NPL) in December 1989, as a high priority hazardous waste site requiring remediation. In 1992, the Department of Energy (DOE), the U. S. Environmental Protection Agency, and the division negotiated the Federal Facility Agreement (FFA) for environmental restoration activities on the ORR. DOE is responsible for cleaning up the ORR following the CERCLA process, which assesses the impacts of ORR areas on human health and the environment. To fulfill this requirement, potential contamination information was collected and reviewed to determine whether CERCLA response activities were needed following field investigation of ORR areas.

A proposal was submitted to the division in March 1996, outlining a process designed to identify portions of the ORR that have been environmentally affected by past federal activities. The DOE Environmental Restoration Footprint Reduction process was designed to investigate and assess those areas of the ORR likely to have been environmentally affected by past federal activities. In

addition, determinations were made as to which land parcels could be conditionally released from CERCLA requirements and removed from NPL status. The focal regulatory requirement for the project was the CERCLA 120-(h) investigative process that is used to identify the presence or absence of hazardous substances on property being transferred by federal agencies. The CERCLA 120-(h) investigative process uses the following information sources to identify the presence of hazardous substance contamination on federal land: historical land use information, aerial photography, remote sensing data including gamma aerial reconnaissance photos, and field investigation/verification.

The division performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and resulting release pathways on that which might render the parcel(s) unfit for release. The contamination could be in the form of solid waste, radiological waste, hazardous waste, or could be present in surface water. Groundwater contamination will be addressed in detail if the property is released to the public.

Areas or facilities found to be contaminated within the various study areas during the parcel evaluation were added to Appendix C of the Federal Facilities Agreement (FFA) as CERCLA maintenance action sites. Uncontaminated study areas or portions of study areas were recommended for No Further Investigation status under the Footprint Reduction Program.

The goal of the program was to reduce the size and configuration of the "footprint" area acreage of the ORR ("behind the fence") designated as part of the NPL site. Essentially, the effort was designed to distinguish "green-field" from "brown-field" areas behind DOE institutional control boundaries.

During the execution of the fieldwork on each footprint study area, certain maintenance action items were determined to be in need of removal. Additional areas were found where abandoned field gear and trash from research projects needs removal. Each footprint parcel was investigated and a final report on the respective study area was generated and issued by the footprint team. The division clearly identified maintenance action problem areas to be addressed by DOE in each of the applicable 20 footprint study area reports (not all parcels had cleanup problems). During calendar year 2001, the division "follow-up footprint project" revisited all the previously determined maintenance action sites to determine compliance with the requested maintenance actions.

Finally, the division has folded the parcel ED-1 Mitigation Action Plan (MAP) requirements into this project as well. Required environmental monitoring by DOE and CROET per the MAP has become a concern. The division will follow up on this project with field excursions in addition to requesting that DOE honor its responsibilities per the MAP document.

Methods and Materials

The purpose of Footprint Reduction was to identify portions of the ORR potentially impacted by past federal activities. The division performed a radiological walkover and reconnaissance survey of twenty parcels and adjoining land. The field investigation focused on possible anthropogenic sources of contamination that might render each parcel unfit for release. The

parcels were investigated and walked over by division staff using field radiological detection instruments (i.e., Ludlum model 2221 scaler-ratemeter with a 2 x 2 inch sodium iodide crystal). A portable gamma spectrometer was used to identify isotopes present at sites where above background radiation was detected. The division also used a micro-rem meter that provides data in tissue dose equivalent units (rem). Global positioning system (GPS) technology was employed to locate field survey points and to confirm the location of anomalous features.

Historical land use investigations, aerial photography analysis, and remote sensing data were studied for evidence of federal activities that could have potentially resulted in adverse impacts to the environment. Magnetic and radiologic anomalies were plotted on maps prepared by the then Lockheed Martin Energy Research (LMER) Geographic Information Science and Technology (GIST) staff for field investigation applications. The division reviewed the map and other data furnished by LMER GIST staff, as well as all pertinent information and data from division files. The magnitude, sheer size of the area to be surveyed, and topography of the land parcels precluded the use of grid survey techniques. After a detailed study of survey techniques and requirements, it was determined that the survey effort would concentrate on mapped locations of magnetic and gamma fly-over anomalies. Aerial photography was investigated and studied thoroughly to evaluate potential land use changes over time.

The division investigated the anomalies identified on the anomalies maps plus suspicious sites observed on historical aerial photos. Cultural changes, non-sequential vegetation changes, radiological anomalies, and geophysical anomalies were investigated. Karst features, springs, abandoned and existing roads, and other unusual sites were inspected when found in the field. Threatened and endangered plant species and Native American sites were on the list of potentially important sites to be considered for exclusion and protective status.

The physically demanding and time-consuming task of walking over the parcels provided the best method of coverage the and best method of obtaining the high quality and reliable information. Routes were selected that would ensure maximum coverage of the parcels. Abandoned roads and trails were walked to determine if hazardous materials or wastes had been dumped on site. Magnetic anomalies were examined to ensure that there were no observable metals, wastes or structures present. Remote areas were investigated to determine if evidence of past federal activities was present. Division staff concluded fieldwork on all of the 20 parcels in early 2000 (totaling approximately 24,754 acres - see Figure 2).

Results and Discussion

Division field teams located the pre-mapped anomalies in the field utilizing GPS technology. Measurements of ambient gamma radiation were taken at each anomalous site or survey site to determine if any contamination from DOE operations (or its federal predecessors) could be detected. Other points were selected and investigated on a random or functional as-needed basis.

Historical investigations, aerial photography analysis, and remote sensing data were studied for evidence of federal activities that could have potentially resulted in adverse impacts to the environment. Magnetic, historical and radiological anomalies were plotted on maps to assist the field investigation team.

During the course of the five (5) plus year Footprint Reduction Project, several maintenance action sites in need of remediation were identified. In addition, several new solid waste management units (SWMUs) were discovered and recommended for exclusion from the parcels (see Figure 1 for locations of all sites). All these sites were to be addressed by DOE at a later date (see Appendix 1 for the maintenance action list). The SWMU sites were given priority by DOE and its subcontractors for appropriate maintenance action. Identification numbers and names were assigned to the sites, and each SWMU was cordoned off with yellow and magenta rope (if radiologically contaminated). These areas were placarded or otherwise flagged. These areas were also added to the FFA Appendix C list. There was one small barn structure at ETTP that was found to have fixed contamination (radiological) on its floor. This facility was immediately provided with appropriate institutional controls as a radiological area.

The intent of this current “follow-up" project was to revisit those areas of concern and determine the status of the requested maintenance actions. All sites were compared to the Appendix C of the FFA to ensure inclusion. Unfortunately, due to budgetary cutbacks or lack of action on DOE’s part, none of the maintenance action sites except for the SWMUs have received the requested attention or response.

Conclusions

During 2001, division staff returned to the locations of the 44 sites listed in Appendix I to investigate and determine if requested maintenance actions had been carried out by DOE to alleviate the problems. Essentially, no action has been taken to address the sites of concern. Therefore, concerns by the division continue to be justified for (public) human health and the environment due to DOE’s lack of response. DOE did appropriately address the new SWMU sites discovered by the division. Each SWMU was cordoned off with yellow and magenta rope (if radiologically contaminated). These areas were placarded, or otherwise flagged. These areas were also added to the FFA Appendix C list.

Division staff will continue to vigorously follow-up on the areas of concern until the desired response by DOE is achieved thereby providing resolution of those concerns. The possibility that groundwater contamination will migrate from impacted areas of the ORR into the study areas exists and constitutes the need for groundwater use restrictions.

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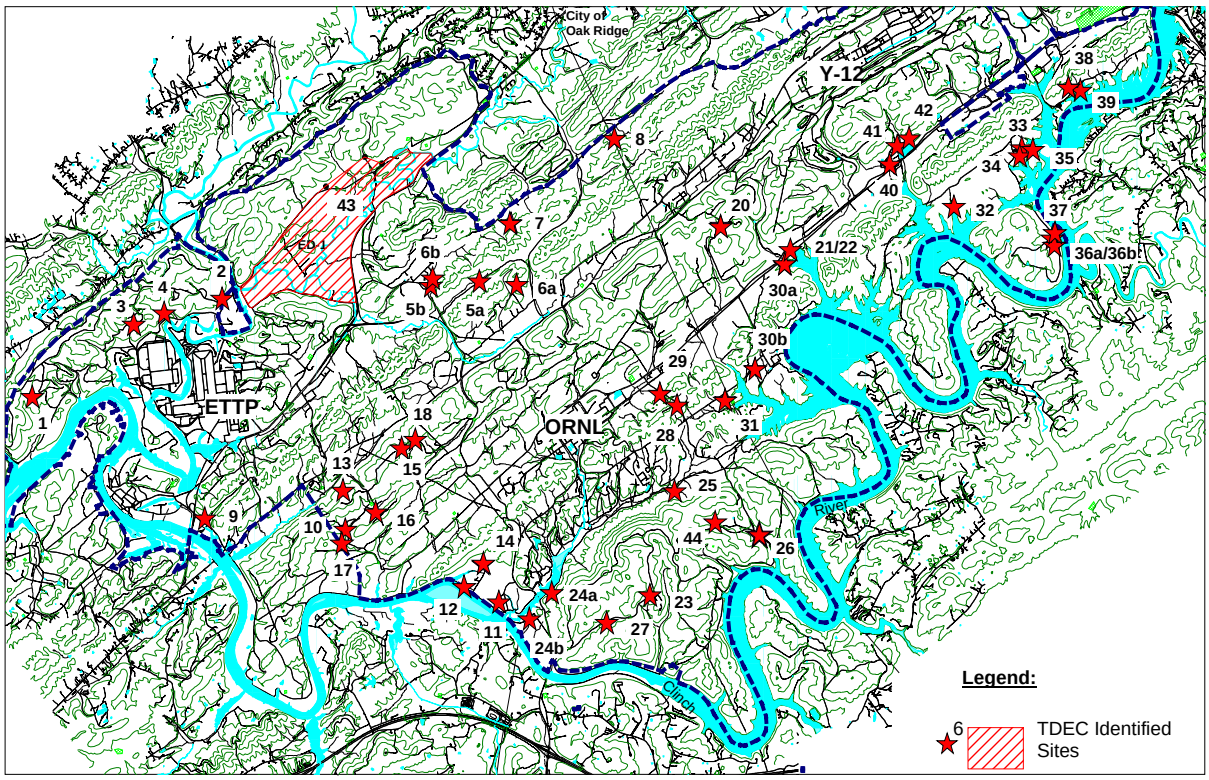

FIGURE 1: Footprint Reduction – Maintenance Action Sites

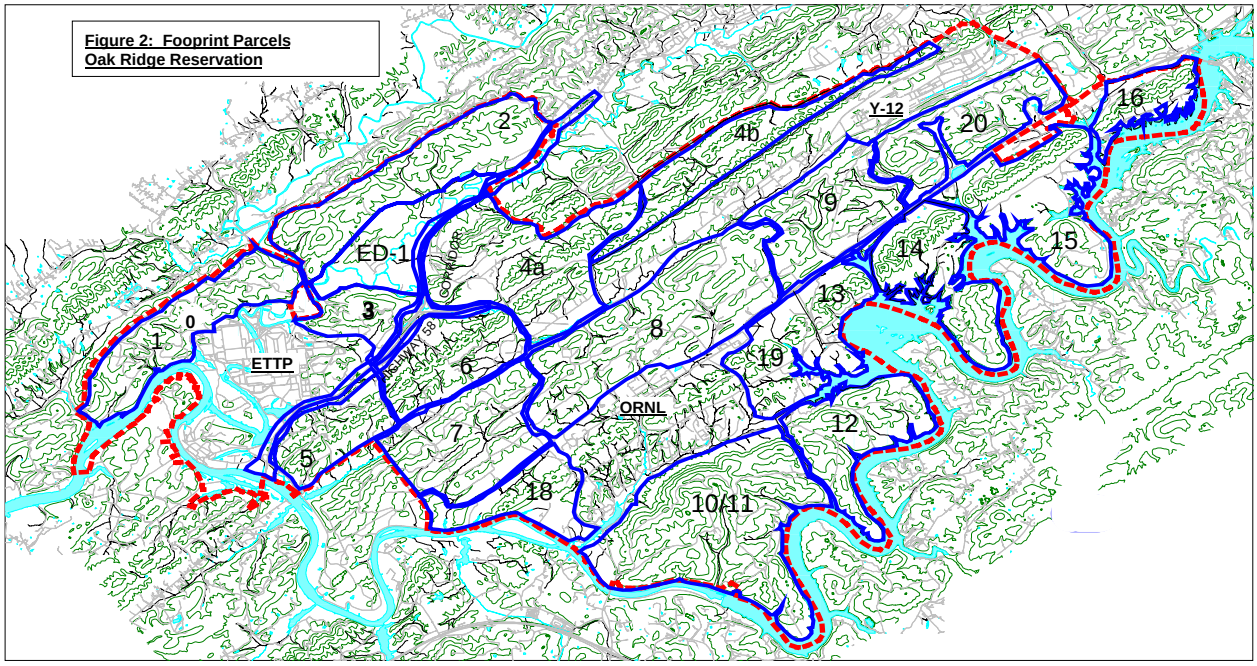

FIGURE 2: Footprint Parcels – Oak Ridge Reservation

APPENDIX I

LIST OF MAINTENANCE ACTION SITES IDENTIFIED BY TDEC FIELD SURVEYS (FOOTPRINT REDUCTION PROCESS)

Map Reference	Maintenance Action Concern and Site Description
	Parcel 1: West Black Oak Ridge Study Area
1	TDEC field station 101: Abandoned 55-gallon steel drum (empty)
2	TDEC field station 127: Old dumpsite (tires, roofing, scrap metal, etc.)
3	TDEC field station 129: Small shed with above background levels of fixed gamma contamination
4	TDEC field station 134: Large abandoned hollow fill
	Parcel 2: East Black Oak Ridge Study Area
	None specified
	Parcel 3: McKinney Ridge Study Area
	None specified
	Parcel 4a: East Fork Ridge/White Wing Study Area
5a/5b	TDEC field stations 24 & 125: Abandoned 55-gallon drums
6a/6b	TDEC field stations 105-124: Numerous abandoned hydrologic experimental equipment
7	TDEC field station 157: Remains of plywood shack and drums
	Parcel 4b: Pine Ridge Study Area
8	TDEC field station 89: Abandoned barrel with residual fuel oil
	Parcels 5/6: West Pine Ridge Study Area
9	TDEC field station 44: Old Dump Site at west end of Happy Valley Campsite
	[Radiological surveys should be conducted prior to use of federal land adjacent to the Consolidated Clinch River Industrial Park to ensure potential exposure is minimized]
	Parcels 7/18: West Chestnut Ridge/West Bethel Valley Study Area
10	TDEC field station 14: Abandoned 55-gallon drum
11	TDEC field station 26: Pile of scrap metal
12	TDEC field station 35: Abandoned automatic sampling equipment along small creek
13	TDEC field station 49: Experimental hydrologic site with abandoned equipment & test gear
14	TDEC field station 89: Abandoned hydrologic/precipitation experimental equipment
15	TDEC field station 103: Abandoned soil percolation test trenches and test gear
16	TDEC field station 105: Abandoned hydrologic experimental gear strewn about the hillside
17	TDEC field station 114: Abandoned experimental site and test gear
18	TDEC field station 193: Abandoned percolation test trench and equipment

Map Reference	Maintenance Action Concern and Site Description
19a/19b	TDEC field stations 250/251: Abandoned hydrologic test site with copious amounts of abandoned equipment
	Parcel 8: Central Chestnut Ridge Study Area
20	TDEC field station 15: Debris & scrap metal strewn about the NOAA/ATDD facility
21	TDEC field station 168: SWMU 0.81 site including broken asphalt, concrete, scrap metal, & local dumping of trash; [same location as map reference 22]
	Parcel 9: Walker Branch Study Area
22	TDEC field station 77: Removal action requested for miscellaneous trash and debris associated with SWMU 0.81 located between Old and New Bethel Valley Roads [same location as map reference 21]
	[Removal action is recommended for abandoned experimental gear, scrap metal, hydrologic test equipment and trash strewn about the entire parcel]
	Parcel 11: Copper Ridge Study Area
23	TDEC field station 27: General vicinity of the Civil Defense Bunker needs trash picked up
24a/24b	TDEC field stations 119 & 297: Abandoned drums
25	TDEC field station 133: Gamma-contaminated site along old roadbed on ridge overlooking HFIR to the north
26	TDEC field station 250: Abandoned & unidentified waste dump (scrap metal, blocks, bricks, etc.)
27	TDEC field station 313: Tire dump
44	"Cesium Forest"
	Parcel 12: Park City Road Study Area
	None specified
	Parcel 13/19: West Haw Ridge/Bearden Creek Watershed Study Area
28	TDEC field station 12: Previously unidentified SWMU contaminated with Cs-137
29	TDEC field station 21: Small dump site adjacent to Melton Valley Access Road which is slightly rad-contaminated
30a/30b	TDEC field stations 50 & 139: Abandoned empty 55-gallon drums
31	TDEC field station 89: Previously SWMU dump (lab equipment, scrap metal, etc)
	Parcel 14: Gallaher Bend/Bull Bluff Study Area
	None specified
	Parcel 15: Freels Bend Study Area
32	TDEC field station 6: Abandoned 55-gallon drum partially submerged in a cove along the shoreline of Melton Lake
33	TDEC field station 20: VDRIF facility needs to have shielding blocks removed from the roof of the structure
34	TDEC field station 21: Demolition debris needs cleared and removed
35	TDEC field station 23: Location of small subterranean vault which held lead source rods; reportedly sand filled

Map Reference	Maintenance Action Concern and Site Description
36a/36b	TDEC field stations 35 & 36: Existing barns need to be cleared of trash & veterinary IV needles/medicine bottles
37	TDEC field station 52: Trash and debris disposed in large sinkhole (standing water)
	Parcel 16: Scarboro/East Haw Ridge Study Area
38	TDEC field station 6: Anomaly 12 at contaminated trailer
39	TDEC field station 7: Building 1404-7 at the location of a radiologically-contaminated hopper
	Parcel 20: East Chestnut Ridge Study Area
40	TDEC field station 36: Abandoned scrap pile/refuse along the Brush Burn Access Road
41	TDEC field station 38: Abandoned scrap metal/asbestos pile located north of Rogers Quarry
42	TDEC field station 39: Abandoned scrap metal pile located north of the Rogers Quarry highwall
43	Parcel "ED-1"

Chapter 7 RADIOLOGICAL MONITORING

K-1066-E Cylinder Yard Soil Sampling

Principal Author: John S. McCall

Abstract

As part of the Tennessee Consent Order of 1999, The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division reviews reports on surveillance and maintenance activities at the ETTP DUF_6 cylinder storage yards. In the event of cylinder breaches, the order specifies requirements for sampling to determine whether the surrounding environment has been impacted. Included in these requirements is the analysis of surface soil in any water runoff path. The radiological analysis of a sample of soil that was collected as a background sample after a breached cylinder event in 2000 indicates the possibility of significant contamination due to other events. TDEC plans to analyze the soil surrounding the yard to determine if widespread contamination is present in the soil immediately surrounding the paved yard.

Introduction

In October 2000, a cylinder breach was discovered in the K-1066-E cylinder yard. One of the actions performed by the contractor in response to the breach was the analysis of surface soil samples at the edge of the yard. Soil samples collected in the water runoff path did not indicate a significant radiological contamination problem (alpha, beta concentrations at approximately 50 pCi/g, the remediation level for the Zone 1 industrial area of ETTP). However, the levels of contamination in the background sample were determined to be approximately 10 times that concentration. Those results indicate a potential for significant contamination of the site. The goal of this sampling program is to determine whether previous events at the K-1066-E cylinder storage yard have caused gross radiological contamination of the soils around the yard.

Methods and Materials

For this investigation, samples will be collected from 10 locations around the cylinder yard. Two samples will be collected from each location with sufficient sample collected for both a gross alpha-beta scan and a scan for specific radionuclides. Both a surface sample (from the 0 – 5 cm depth) and subsurface sample (from the 5 – 20 cm depth) will be collected. Samples will be collected using manual equipment. The sampling locations will be determined by the following technique. The perimeter of the cylinder yard will be divided into 10 zones (3 zones along the long sides and 2 zones across the short sides). A random location will be chosen from each zone using a computerized randomization program. Sampling will be scheduled for March or April 2002.

Samples will initially be analyzed for gross alpha and beta. Unused material will be held until the gross alpha/beta results are evaluated. Selected samples with sufficiently high activity may be analyzed for specific radionuclides. TDEC will furnish sample containers. Samples will be collected using approved TDEC and EPA sampling procedures. Necessary equipment and gloves will be used to prevent any cross contamination. Decontamination of equipment will be performed as necessary between samples or after sampling. Samples will be surveyed for rad

contamination and only those with measurements at the surface of less than 1 mR/hr will be submitted to the laboratory.

Results and Discussion

The development of the sampling plan is complete. The project has been approved by division management and is included in the 2002 Environmental Monitoring Plan. The contractor has provided their requirements for advance notification of the sampling details in order to provide radiological monitoring and coordinate with other activity at the cylinder yard.

Results will be available after the sampling program is finished in the spring of 2002.

Conclusion

No conclusions can be determined until sampling and analysis is complete. Sampling is expected to show whether widespread contamination is present around the perimeter of the yard.

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Chapter 7 RADIOLOGICAL MONITORING

Ambient Radiation Monitoring on the Oak Ridge Reservation using Environmental Dosimetry (RMO)

Principal Author: Gary Riner

Abstract

The Tennessee Department of Environment and Conservation began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. This program provides estimates of the dose to members of the public from exposure to gamma/neutron radiation attributable to Department of Energy activities on the reservation and baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the state primary dose limit for members of the public (100 mrem/yr). Since the dose reported for each site is based on continuous exposure over the course of the year, the results are considered conservative by nature.

All the doses reported for 2001 at off-site locations were below the state primary dose limit for members of the public. However, several locations on the reservation that are considered to be potentially accessible to the public exhibited results in excess of this limit. These sites are primarily associated with uranium hexafluoride cylinder storage yards at the East Tennessee Technology Park: where DOE's reindustrialization initiative has resulted in an influx of businesses not directly related to DOE operations. As in the past, various sites located in restricted areas of the reservation exhibited annual doses in excess of the dose limit for members of the public. These sites are subject to remediation in accordance with provisions specified in CERCLA and the Federal Facilities Agreement for the Oak Ridge Reservation. Decreases in the doses observed at several of these locations in 2001 can be attributed to remedial activities.

Introduction

Radiation is emitted by various radionuclides that have been produced, stored, and disposed of on the Oak Ridge Reservation (ORR). Associated contaminants are evident in ORR facilities and surrounding soils, sediments, and waters. In order to assess the risks posed by these contaminants, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division began monitoring ambient radiation levels on and in the vicinity of the ORR in 1995. This program provides:

- conservative estimates of the potential dose to members of the public from exposure to gamma radiation attributable to DOE activities/facilities on the ORR;
- baseline values used to assess the need and/or effectiveness of remedial actions;
- information necessary to establish trends in gamma radiation emissions;
- information relative to the unplanned release of radioactive contaminants on the ORR.

In this effort, environmental dosimeters were used to measure the radiation dose attributable to external radiation at selected monitoring stations. Associated data was compared to background values and the state's primary dose limit for members of the public.

Methods and Materials

The dosimeters used in the program were obtained from Landauer, Inc., Glenwood, Illinois. Each of the dosimeters used an aluminum oxide photon detector to measure the dose from gamma radiation over the period monitored (minimum reporting value = 1 mrem). At locations where there was a potential for the release of neutron radiation, the dosimeters also contained an allyl diglycol carbonate based neutron detector (minimum reporting value = 10 mrem). Dosimeters that contained photon detectors alone were collected quarterly and sent to Landauer for processing. Dosimeters that contained both photon and neutron detectors were collected and processed semiannually (to allow more precise neutron measurements). To account for exposures that could have been received in transit or storage, control dosimeters of both types were provided with each shipment from the Landauer Company. The control dosimeters were stored at the division's office and returned to Landauer with the associated field deployed dosimeters for processing. Any exposure received by the control dosimeters was subtracted from the dose reported for the field-deployed dosimeters.

As the quarterly results were received, staff prepared a report of the data, which was provided to interested parties. At the end of the year, the quarterly results were summed for each location and the resultant annual doses compared to background values and the state primary dose limit for members of the public (100 mrem/year). Associated data is presented in Table 1. Monitoring stations in the program included operating facilities; locations on the ORR that are potentially accessible to the public; local communities; and sites subject to or undergoing remediation. These locations are depicted in Figures 1 through 3, along with the annual dose for each site.

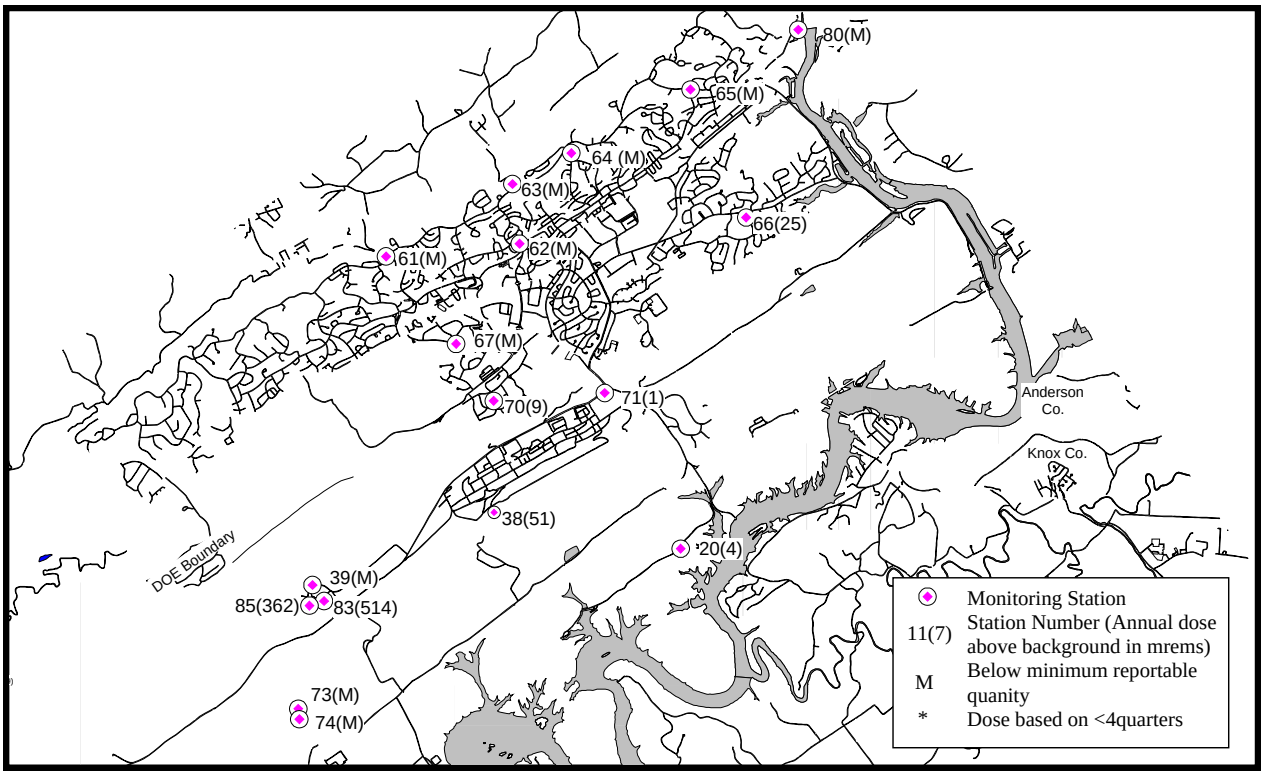

Figure 1: Approximate Locations of Environmental Dosimeters deployed in the Vicinity of the Y-12 Facility during the Year 2001

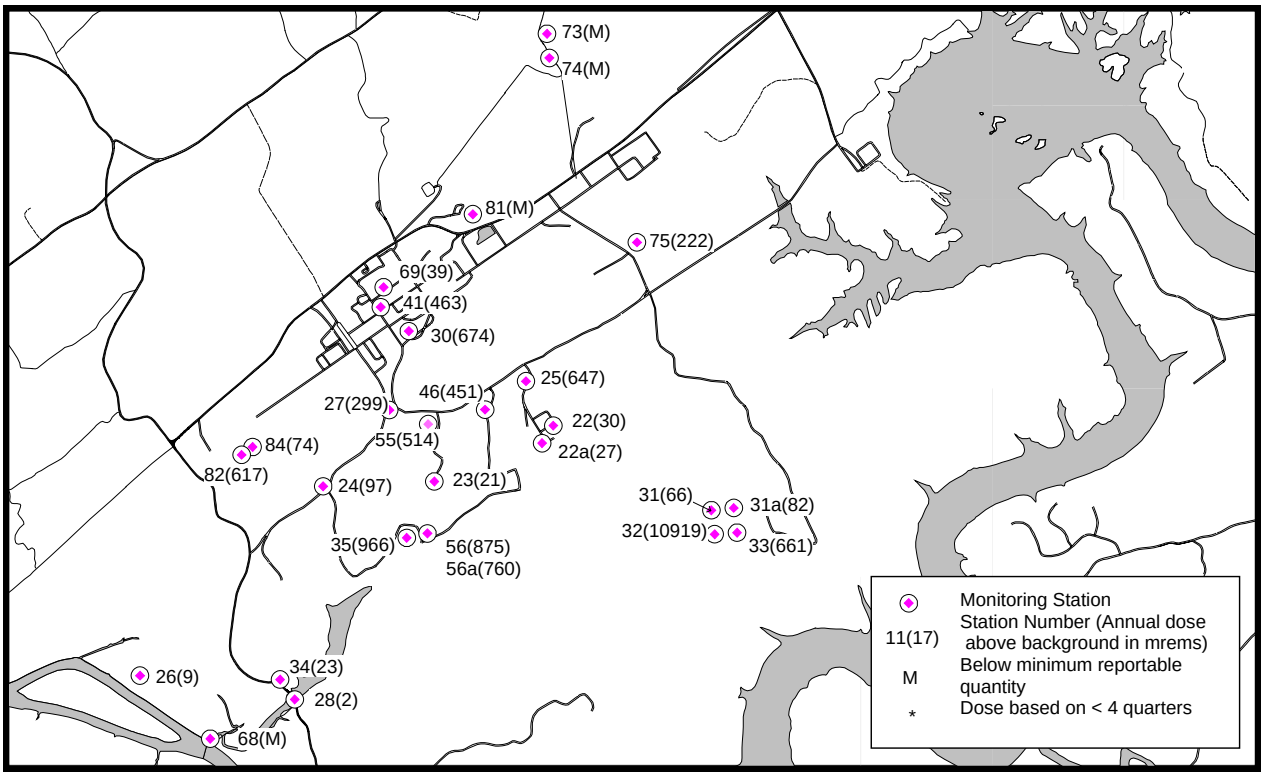

Figure 2: Approximate Locations of Environmental Dosimeters deployed in the Vicinity of the Oak Ridge National Laboratory during the Year 2001

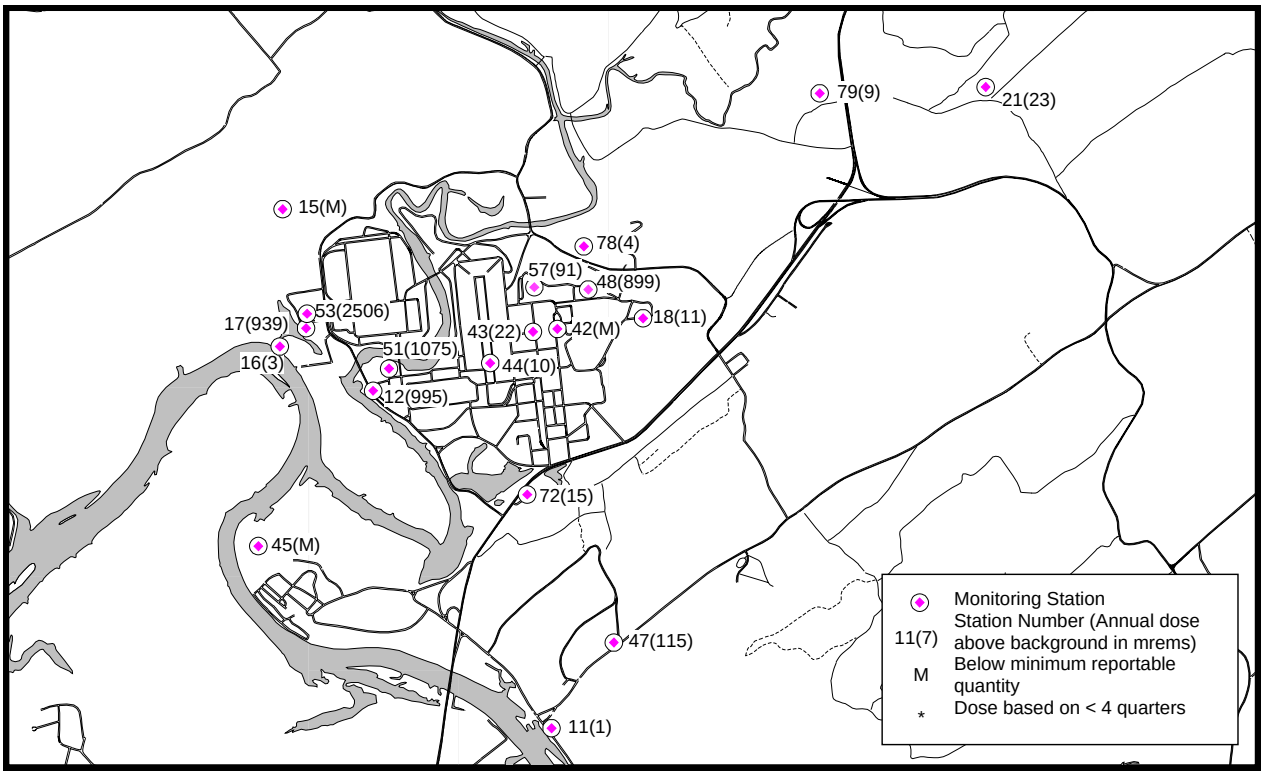

Figure 3: Approximate Locations of Environmental Dosimeters deployed in the Vicinity of the East Tennessee Technology Park during the Year 2001

Table 1: Results from Tennessee Department of Environment and Conservation Monitoring using Environmental Dosimetry for the year 2001

Station No. (Dosimeter)	**Location** *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly* *Neutron Dosimeters are reported semi-annually*	**Type of Radiation**	**Dose Reported for 2001 (mrems)** *M = Below Minimum Reportable Quantity*					***Total 2000***
			1st Qtr 2001	2nd Qtr 2001	3rd Qtr 2001	4th Qtr 2001	**Total 2001**	
9. (OSL)	Norris Dam Air Monitoring Station (Background)	Gamma	3	M	M	3	6	*8*
11. (OSL)	ETTP Grassy Creek Embayment	Gamma	1	M	M	M	1	*7**
12. (Neutron)	ETTP UF_6 Cylinder Storage Yard K-1066-E	Neutron	20		M		995	*1,138*
		Gamma	442		533			
15. (OSL)	ETTP K-1070-A Burial Ground	Gamma	M	M	M	M	M	*4*
16. (OSL)	ETTP K-901 Pond	Gamma	3	M	M	M	3	*7**
17. (Neutron)	ETTP K-1066-K UF_6 Cylinder Yard (near K-895)	Neutron	20		M		939	*1,229*
		Gamma	533		386			
18. (OSL)	ETTP TSCA on fence across from Tank Farm	Gamma	4	3	4	M	11	*16*
20. (OSL)	ORNL Freels Bend Entrance	Gamma	2	2	M	M	4	*6*
21. (OSL)	ETTP White Wing Scrap Yard	Gamma	8	4	4	7	23	*30*
22. (OSL)	ORNL High Flux Isotope Reactor	Gamma	4	10	7	9	30	*26*
22a. (OSL)	ORNL High Flux Isotope Reactor (duplicate)	Gamma	7	5	9	6	27	*25*
23. (OSL)	ORNL Solid Waste Storage Area 5	Gamma	8	6	2	5	21	*59*
24. (OSL)	ORNL Building X-7819	Gamma	24	27	40	6	97	*97*
25. (OSL)	ORNL Molten Salt Reactor Experiment	Gamma	147	149	185	166	647	*266*
26. (OSL)	ORNL Cesium Fields	Gamma	8	M	M	1	9	*7*
27. (OSL)	ORNL White Oak Creek Weir @ Lagoon Rd	Gamma	79	60	85	75	299	*297*
28. (OSL)	ORNL White Oak Dam	Gamma	2	M	M	M	2	*10*
30. (OSL)	ORNL X-3513 Impoundment	Gamma	148	212	110	204	674	*2,328*
31. (OSL)	ORNL @ Cesium Forest boundary	Gamma	18	14	18	16	66	*78*
31a. (OSL)	ORNL @ Cesium Forest boundary (duplicate)	Gamma	20	18	25	19	82	*79*
32. (OSL)	ORNL Cesium Forest on tree	Gamma	2,195	2,587	3,131	3,006	10,919	*10,259*
33. (OSL)	ORNL Cesium Forest Satellite Plot	Gamma	145	151	186	179	661	*704*
34. (OSL)	ORNL SWSA 6 on fence @ Highway 95	Gamma	9	4	1	9	23	*14*
35. (OSL)	ORNL White Oak Creek @ Melton Branch	Gamma	245	238	253	230	966	*1,027*
38. (OSL)	Y-12 Uranium Oxide Storage Vaults	Gamma	18	13	14	6	51	*29*
39. (OSL)	Y-12 @ back side of Walk In Pits	Gamma	M	M	M	M	M	*3*
41. (OSL)	ORNL North Tank Farm	Gamma	26	338	78	21	463	*92*
42. (OSL)	ETTP east side of the K-1401 Building	Gamma	M	M	M	M	M	*1*
43. (OSL)	ETTP west side of the K-1401 Building	Gamma	9	5	2	6	22	*14*
44. (OSL)	ETTP K-25 Building	Gamma	6	1	M	3	10	*10*
45. (OSL)	ETTP K-770 Scrap Yard	Gamma	Lost	Lost	M	M	M*	*M**
46. (OSL)	ORNL Homogeneous Reactor Experiment Site	Gamma	112	125	123	91	451	*366*
47. (OSL)	Y-12 Bear Creek Road ~ 2800 feet from Clinch River	Gamma	27	25	31	32	115	*110*
48. (OSL)	Temp. # 1: ETTP K-1420 Building	Gamma	223	210	199	267	899	*1,171*
51. (Neutron)	ETTP north side of the K-1066-E UF_6 Cylinder Storage Yard	Neutron	M		M		1,075	*1,710*
		Gamma	347		728			
53. (Neutron)	ETTP southwest corner of the K-1066-K UF_6 Cylinder Storage Yard	Neutron	40		M		2,506	*3,692*
		Gamma	1,493		973			
53a. (Neutron)	ETTP southwest corner of the K-1066-K UF_6 Cylinder Storage Yard (duplicate)	Neutron	40		M		2,542	*1819**
		Gamma	1,423		1,079			
55. (OSL)	Temp. #8: ORNL SWSA 5 True Waste Trench	Gamma	121	113	150	130	514	*398*
56. (OSL)	Temp. #9: ORNL Old Hydrofracture Pond	Gamma	301	263	168	143	875	*3,612*
56a. (Neutron)	ORNL Old Hydrofracture Pond (duplicate)	Neutron	M		M		760	*584**
		Gamma	475		285			

Table 1: Results from Tennessee Department of Environment and Conservation Monitoring using Environmental Dosimetry for the year 2001 (Continued)

Station No. (Dosimeter)	**Location** *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly* *Neutron Dosimeters are reported semi-annually*	**Type of Radiation**	**Dose Reported for 2001 (mrems)** *M = Below Minimum Reportable Quantity*					***Total 2000***
			1st Qtr 2001	2nd Qtr 2001	3rd Qtr 2001	4th Qtr 2001	**Total 2001**	
57. (OSL)	Temp. #10: ETTP UF_6 Cylinder Yard K-1066-B	Gamma	21	24	23	23	91	*67*
61. (OSL)	Temp. #14: Outer & Illinois Ave	Gamma	M	M	M	M	M	*M*
62. (OSL)	Temp. #15: East Pawley	Gamma	M	M	M	M	M	*2*
63. (OSL)	Temp. #16: Key Springs Road	Gamma	M	M	M	M	M	*M*
64. (OSL)	Temp. #17: Cedar Hill Greenway	Gamma	M	Lost	M	M	M*	*M*
65. (OSL)	Temp. #18: California Ave.	Gamma	M	M	M	M	M	*M*
66. (OSL)	Temp. #19: Emory Valley Greenway	Gamma	5	Lost	14	6	25*	*23*
67. (OSL)	Temp. #20: West Vanderbilt	Gamma	Lost	M	5	3	8*	*M*
68. (OSL)	ORNL White Oak Creek @ Coffer Dam	Gamma	M	M	M	M	M	*9*
69. (OSL)	ORNL Graphite Reactor	Gamma	18	10	5	6	39	*61*
70. (OSL)	Scarboro Perimeter Air Monitoring Station	Gamma	9	Lost	M	M	9*	*11*
71. (OSL)	Y-12 East Perimeter Air Monitoring Station	Gamma	1	M	M	M	1	*3*
72. (OSL)	ETTP Visitors Center	Gamma	2	6	7	Lost	15*	*New*
73. (OSL)	Temp. #3: Spallation Neutron Source (north side)	Gamma	M	Lost	Lost	M	M*	*New*
74. (OSL)	Temp. #4: Spallation Neutron Source (south side)	Gamma	Lost	M	M	M	M*	*New*
75. (OSL)	Temp. #5: ORNL hot spot on Haw Ridge	Gamma	52	46	78	46	222	*New*
76. (OSL)	Temp. # 6: Boeing Site	Gamma	1	M	Discontinued	Discontinued	1*	*New*
77. (OSL)	Temp. # 7: Boeing Site	Gamma	M	1	Discontinued	Discontinued	1*	*New*
78. (OSL)	Temp. #11: ED3 Quarry at Blair Road	Gamma	M	M	4	M	4	*New*
79. (OSL)	Temp.#12: ED1 on pole	Gamma	4	M	5	M	9	*New*
80. (OSL)	Temp.#13: Elza Gate	Gamma	M	M	M	M	M	*New*
81. (OSL)	ORNL visitors center	Gamma	Lost	M	M	M	M*	*M*
82. (OSL)	ORNL Wag 3	Gamma	New	187	231	199	617*	*New*
83. (OSL)	Y-12 Walk in Pit W/ Radon Detector	Gamma	New	152	362	Discontinued	514*	*New*
84. (OSL)	Temp. #2 ORNL Wag 3	Gamma	New	18	28	28	74*	*New*
85. (OSL)	Y-12 Walk in pits with Radon detector	Gamma	New	New	362	Discontinued	362*	*New*

Notes: Two types of dosimeters are used in this program, optically stimulated luminescent dosimeters (OSLs) and neutron dosimeters. The OSLs measure the dose from gamma radiation, which is considered sufficient for most of the monitoring stations. The neutron dosimeters, which have been placed at selected locations, measure the dose from neutrons in addition to the gamma radiation. At the locations where the neutron dosimeters have been deployed, the total dose is the sum of the doses reported for neutrons and the dose reported for gamma radiation.

The primary dose limit for members of the public specified in both DOE Orders and 10 CFR Part 20 (Standards for Protection Against Radiation) is 100 mrem total effective dose equivalent exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division offices, is subtracted from the exposure reported above for the field-deployed dosimeters.

*=The total dose reported for this station was based on the sum of less than four quarters of data. M=Below minimum reportable quantity. NA=Not applicable. ORNL=Oak Ridge National laboratory. ETTP=East Tennessee Technology Park.

Results and Discussion

The dose of radiation received at any given location is dependent on the intensity and the duration of the exposure. For example, an individual standing at a site where the dose rate is 1 mrem/hr would receive a dose of 2 mrem, if he stayed at the same spot for 2 hours. If he were exposed to the same level of radiation for 8 hours a day for the approximately 220 working days in a year (1,760 hours), he would receive a dose of 1,760 mrem in that year. It should be understood, the doses reported in the division's Ambient Radiation Monitoring Program are based on the exposure an individual would receive if he remained at the monitoring station 24 hours a day for a year (8,760 hours). Since this is very unlikely to be the actual case, the doses reported should be viewed as conservative estimates of the maximum dose an individual would receive at each location.

In the past, the division relied on the measurement of gamma radiation to estimate the radiation doses at the various monitoring stations. While gamma radiation is expected to be the major contributor to external exposures, an additional dose from neutrons was anticipated at sites near the uranium hexafluoride cylinder storage yards located at the East Tennessee Technology Park (ETTP). In 2000, staff began placing neutron dosimeters at monitoring stations near the storage yards. Results for both 2000 and 2001 from these dosimeters were somewhat erratic, but indicative of a measurable neutron flux at several of the locations. This flux is attributed to the interaction of alpha particles emitted by uranium reacting with the nuclei of fluorine ($\alpha + {}^{19}F \rightarrow {}^{22}Na + n$) and/or the spontaneous fission of uranium isotopes. The neutron doses measured have been incorporated into the total doses reported in Table 1.

The monitoring locations and associated results for the program can be roughly organized into three categories: (1) stations located off the ORR; (2) sites on the ORR that are to some degree accessible to the public; and (3) locations within access-controlled areas of the reservation.

Stations off the ORR

The total dose for 2001 measured at the background station (Norris Dam Ambient Air Monitoring Station) was 6 mrem, which is consistent with the annual dose reported for the location in 2000, 8 mrem. The doses reported for other monitoring stations off the reservation (e.g., in residential areas) were all well below the 100 mrem dose limit for members of the public and to a large degree below the detection capabilities of the environmental dosimeters (1 mrem).

Stations Potentially Accessible to the Public

Since access to the reservation has been predominately restricted to employees of DOE or their contractors in the past, locations within the fenced areas of the reservation have traditionally been considered inaccessible to the general public. With the reindustrialization of portions of the reservation, there has been an influx of workers employed by businesses not directly associated with DOE operations. If these individuals are considered members of the general public, several of the sites within the boundaries of the ORR become problematic. For example, relatively high doses of radiation were measured at ETTP in the vicinity of the K-1420 Building (899 mrem) and the uranium hexafluoride cylinder storage yards. Under current conditions, these sites are potentially accessible to workers not employed by DOE or their contractors. In addition, the

cylinders contained in the storage yards have deteriorated over the years and at least six of the cylinders are known to have leaked uranium hexafluoride in the past.

In 2001, dose measurements taken in the vicinity of the cylinder yards ranged from 939 to 2,542 mrem. Two of these locations, Stations 12 (995 mrem) and 51 (1,075 mrem), are located on the fence that separates the K-1066-E uranium hexafluoride cylinder storage yard from the Poplar Creek area, making them accessible from outside the facility boundary. Due to the elevated dose measurements observed the vicinity of the cylinder yards, the division implemented a separate monitoring project in 1999 designed to gather more comprehensive data from the cylinder yards. Associated information can be found under the heading *Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride (UF_6) Cylinder Yards at ETTP* (Platt, 2002). Based on the information at hand, the state considers the uranium hexafluoride cylinders to be a public hazard and have advocated their removal and / or stabilization.

Stations within Access Controlled Areas of the Reservation

While conditions could change, other sites monitored that reported results appreciably above the primary dose limit are currently located within access-controlled areas of the reservation. These sites are subject to remediation in accordance with the provisions of CERCLA and the Federal Facility Agreement (FFA) for the ORR. While it is beyond the scope of this report to address each of these sites individually, several merit comment.

The Cesium Forrest [Stations 32 (10,919 mrem), and 33 (661 mrem)]: The highest dose reported for 2001, 10,919 mrem, was from a dosimeter that has been placed on a tulip poplar tree (Station 32) at the Oak Ridge National Laboratory (ORNL) Cesium Forest. In 1962, a group of trees at this location were injected with a total of 360 millicuries of cesium-137, as part of a study on the isotope's behavior in a forest ecosystem (Witkamp, 1964). Based on current data, it appears a significant amount of the cesium-137 remains in the trees and local environment.

The 3513 Waste Holding Basin [Station 30 (674 mrem)]: Until 1977, the 3513 Waste Holding Basin served as a settling pond for ORNL effluents prior to their release to White Oak Creek. Sludge from the bottom of the basin has been estimated to contain over 200 curies of cesium-137, along with various other radionuclides including transuranics (Bechtel, 1992). In 1997, a CERCLA Record of Decision provided for the removal and disposal of sludge in the 3513 Basin and the adjacent 3524 Impoundment (which also received process wastes historically). In 2000/2001, sludge from the 3524 Basin was temporarily placed in the 3513 pond and the 3524 Basin was filled and capped. In 2001, DOE contractors began removing the sludge from the 3513 Basin (including the sludge previously in 3524). Once removed, the sludge is being dewatered, formed into bricks, and stored in preparation for disposal. In 2001, the dose reported at Station 30 (which is near the 3513 basin) went down from the 2,328 mrem measured in 2000 to 674 mrem. It should be noted, the sludge bricks are currently being stored some distance from the monitoring station, which would account, in part, for the decreased dose reported. The radiation associated with the site should continue to decrease as the action progresses.

The North Tank Farm [Station 41 (463 mrem)] The North Tank Farm is located near the center of ORNL's main campus. In the past, a number of underground storage tanks were emplaced at

this location to store and / or treat radioactive and hazardous wastes. In the late 1990s, one of these tanks, W-1A, was discovered to be the source of groundwater contamination, the Corehole 8 Plume, that covers a large area adjacent and to the west of the site. Contaminants associated with this plume include strontium-90, americium-241, plutonium-238, 239, 240, and curium-244 (Bechtel, 1992). These contaminants discharge to First Creek and are transported to White Oak Creek and beyond. DOE subsequently proposed to remove W-1A and the adjacent soils, which have developed into a secondary source of the contaminants feeding the plume.

The soils above subsurface contaminants attenuate (shield) radiation emitted by the materials beneath. Consequently, it is expected that exposure rates will increase as contaminants are uncovered and brought to the surface during remediation. In the first quarter of 2001, the dose reported at station 41 near the North Tank Farm was 26 mrem. This dose climbed to 338 mrem in the second quarter of 2001, as the tank and contaminated soils were uncovered in preparation for their removal. In this case, the contaminants included transuranic wastes that exhibited much higher radioactivity than had been anticipated by DOE contractors hired to perform the action. As a consequence, the contractors replaced and covered the materials that had been excavated, until alternate methods can be developed to handle the wastes. As would be expected, the dose reported for station 41 dropped to 78 mrem in the third quarter and 21 mrem in the forth quarter.

The Old Hydrofracture Facility (OHF) Surface Impoundment [Station 56 (875 mrem)]: From 1964 to 1980 radioactive wastes were transported through pipelines from the ORNL main complex to the Old Hydrofracture Facility, which is located in Melton Valley, east of Solid Waste Management Unit (SWSA) 5 South. Underground storage tanks at the OHF held this waste prior to it being mixed with grout and injected into the bedrock (approximately 1,000 feet beneath the ground surface). During this process, the tanks and the OHF surface impoundment (constructed to retain spills/overflow) were contaminated with fission products, activation products, and transuranic radionuclides. In this regard, the OHF pond exhibited some of the highest gamma emissions measured in the SWSA 5 area (DOE, 1998a). In 2000, contaminated sediments in the pond were grouted in place and the basin filled and capped. While the action did not remove the contaminants (as originally planned), the grout and cover shields radiation being emitted by the radionuclides contained in the sediments. As a consequence, the dose measured at station 56 went down in 2001 from 3,612 mrem reported in 2000 to 875 mrem.

Conclusion

The monitoring of radiation using environmental dosimeters has proven to be a relatively economic and effective method of estimating ambient gamma radiation levels on and in the vicinity of the ORR. Doses reported for 2001 at off-site locations were all below the state limit for members of the public. Although, several locations on the reservation that are considered potentially accessible to the public exhibited results in excess of the primary dose limit. These sites are primarily associated with uranium hexafluoride cylinder storage yards at ETTP, where DOE's reindustrialization initiative has resulted in an influx of businesses not directly related to DOE operations. As in the past, various sites located in restricted areas of the reservation exhibited annual doses in excess of the primary dose limit. These sites are subject to remediation in accordance with provisions specified in CERCLA and the FFA. Decreases in the doses reported at several of these locations can be attributed to associated remedial activities.

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Chapter 7 RADIOLOGICAL MONITORING

Pilot Project for Radon Monitoring (RMO)

Principal Author: Howard Crabtree

Abstract

In 2001, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division began a pilot study to assess the feasibility of monitoring radon emissions on the Oak Ridge Reservation. The project was prompted by a concern that the disposal of large amounts of uranium in reservation burial grounds may have resulted in elevated radon levels (radon is produced by the natural decay of radionuclides in the uranium decay series).

For the study, radon detectors were placed at background locations and over selected locations in the Bear Creek Burial Grounds. After five months in the field, the detectors were collected and processed. The results from the burial grounds were then compared with the background data to determine if radon levels above natural concentrations could be identified. The results indicate the radon levels can be measured and suggest the burial grounds have areas of elevated radon. However, the quantity of data currently available and uncertainties associated the results render conclusions as to the significance of the radon levels reported premature at this time.

Introduction

Radon is a colorless, odorless gas formed by the normal radioactive of decay of radionuclides in the uranium decay chain. As radon itself decays, alpha radiation is released and daughter radionuclides are produced (e.g., polonium-218, polonium-214, bismuth-214, and lead-214). These radon daughters also emit radiation (alpha, beta, & gamma), which contributes significantly to the total radiation dose associated with radon exposures. Since radon is a gas and the daughters (metals) tend to attach to air-borne particles, exposures to these radionuclides are primarily considered an inhalation hazard.

As noted above, radon is produced by the decay of radionuclides in the uranium decay series. In this regard, millions of pounds of uranium have been disposed on the Oak Ridge Reservation (ORR). Consequently, there has been a concern that radon and its daughters could be present on the reservation at hazardous levels. In May of 2001, the Tennessee Department of Environment and Conservation, Division of the Department of Energy Oversight began a pilot study designed to assess the feasibility of monitoring radon levels on the reservation. For the study, radon detectors were placed at background locations and over uncapped portions of the Bear Creek Burial Grounds, where over 40 million pounds of uranium was disposed during operations. In October of 2001, the detectors were collected and processed. The results from the burial grounds were then compared to the background data to determine if radon levels above background concentrations could be identified.

Ancillary to the radon monitoring, division staff deploying the radon detectors observed materials that appeared to be uranium wastes on the ground surface over the BG-D East portion of the burial grounds. DOE was notified of the finding and a sample of the materials was collected and sent to the state radiochemistry laboratory for analysis.

Methods and Materials

To measure the radon levels, the project used Radtrak® Radon Gas Detectors obtained from Landauer Inc., Glenwood, Illinois. The detectors were protected from the elements by attaching them to the inside of five-gallon plastic containers, following recommendations provided by the vender. These containers (with the detectors attached to the inside) were placed upside down at the monitoring stations and fixed in place using tent stakes.

Twenty of the detectors were placed over uncapped portions of the Bear Creek Burial Grounds. To collect background information, three of the detectors were located at a nearby location with similar geology, but believed to be free of contamination. Both sets of detectors were left in place for five months (May 15 to October 20), then collected by staff and shipped by certified mail to the vendor for processing. After the results were returned, the data from the burial grounds were compared to the results obtained from the background stations.

Results

The approximate locations of the radon detectors and the associated results are provided in Figure 1. It should be understood, the sampling methodology was designed to capture radon emissions released from soils beneath the five-gallon containers: therefore, the measurements are not representative of ambient air concentrations, which should be much less because of the dilution afforded by the ambient environment.

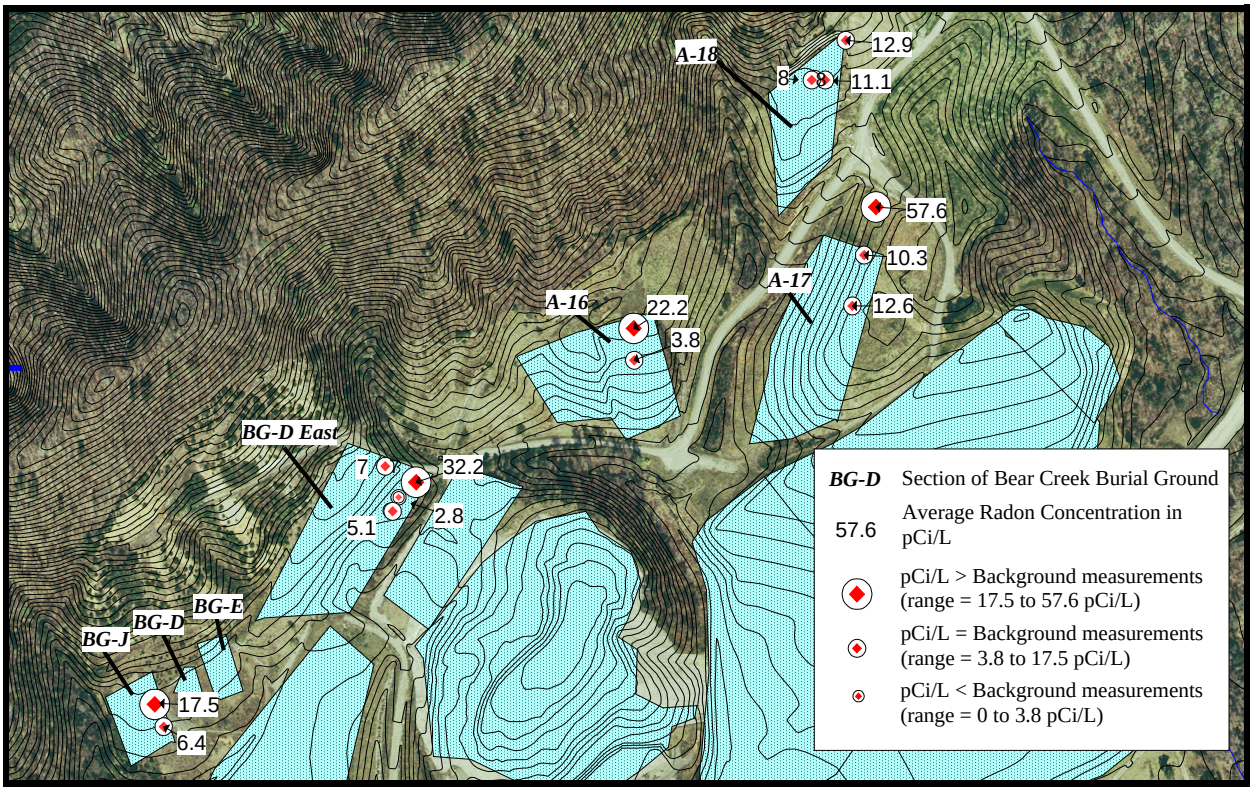

Figure 1: Locations of Radon Detectors placed in the Bear Creek Burial Grounds and associated Results

Data for the project proved to be highly variable. The average radon concentrations from the background locations ranged from 3.8 to 13.8 pCi/L. Data for the detectors placed in the burial grounds ranged from 2.8 to 57.6 pCi/L. While the median values for the two data sets were approximately the same (~11 pCi/L), the average concentration for the burial ground (15 pCi/L) was fifty percent higher than the average for the background station (9.5 pCi/L). In this case, the average for the burial ground was skewed high by two results (32 & 58 pCi/L) that were two and four times the maximum concentration measured at the background stations (13.8 pCi/L). This suggests that elevated radon levels (above background concentrations) are present at specific locations in the burial grounds. However, conclusions are premature, given limitations with the data currently available.

Various problems were encountered during this initial effort. For example, three of the detectors could not be located when staff returned to collect them for processing. In addition, several of the detectors were damaged (presumably by insects or small mammals) during the monitoring period. The effect (if any) of this damage on the results is unknown. Given the quantity of data available and the uncertainty associated with the results, the data should be viewed as preliminary, at this time.

In addition to the problems noted above, staff deploying the radon detectors encountered what appears to be radioactive waste on the surface of the BG-D East portion of the burial grounds. These materials consisted of machine turnings and yellow, green, and black materials believed to be uranium oxides (Figure 2). Staff advised the Department of Energy of their observations and a subsequent radiation survey of the area by DOE contractors supported division findings. While a survey of the exit points from BG-D East did not find contamination, the deck of a mower used at the site was found to be contaminated. Subsequently, DOE upgraded the site's designation from a subsurface soil contamination area to a surface radiation control area.

Figure 2: Radioactive Materials observed in the BG-D East Section of the Bear Creek Burial Grounds *(Photos provided by the Department of Energy)*

A review of the Bear Creek Valley Remedial Investigation (DOE, 1996) describes BG-D East as an uncapped portion of the burial grounds used for the disposal of uranium chips, metal, and oxide wastes. While available information indicates there is little specific data for the site, the results for a sample taken by division staff of the suspect materials was indicative of high concentrations of depleted uranium. These results included concentrations of uranium-238 at 190,000 pCi/g, uranium-235 at 1,860 pCi/g, and uranium-234 at 22,900 pCi/g. These data are consistent with results reported for a sample of similar material taken near BG-D East during the Bear Creek Remedial Investigation. This sample exhibited concentrations of uranium-238 at

205,000 pCi/g, uranium-235 at 2,500 pCi/g, and uranium-234 at 154,000 pCi/g. As this sample was taken in 1994, it would appear the materials have been on the surface for a number of years. It is speculated that the materials may be remnants of uranium fires (which apparently were common at the site) and / or wastes that were deposited on the surface during disposal.

Based on the findings: the division issued a letter to DOE recommending that immediate action be taken to correct conditions at the site; DOE proposed to cover the exposed material with soil; and EPA suggested the situation be addressed as a time critical response action under CERCLA. In the interim, the state, EPA, and DOE have begun discussions of the most appropriate measures to mitigate the associated hazards.

Conclusions

The preliminary results from radon detectors placed in the Bear Creek Burial Grounds indicate that it is feasible to measure radon levels on the ORR. Several results from samples taken over the burial grounds were two to four times higher than data obtained from the background location, suggesting higher concentrations of radon may be present over specific locations. While the elevated radon levels reported may be a result of the disposal of large amounts of uranium at the site, the quantity of the preliminary data and uncertainties associated the results make definitive conclusions premature.

Based on observations made by staff, it is apparent that waste materials are exposed on the surface of the burial grounds. Results of samples taken of these materials by both the state and DOE contractors indicate these wastes contain high concentration of depleted uranium. It is speculated that the materials may be the remnants of uranium fires and/or wastes that were deposited on the surface during past operations. In any case, the associated contaminants are currently subject to dispersion by the elements and measures necessary to assure that the contaminants are contained should be implemented as quickly as possible. To this end, DOE, EPA, and the state have begun discussions to determine the most appropriate methods to control the hazard.

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Chapter 7 RADIOLOGICAL MONITORING

Real Time Ambient Gamma Monitoring of the Oak Ridge Reservation (RMO)

Principal Author: Howard Crabtree

Abstract

The Tennessee Department of Environment and Conservation uses continuous exposure rate monitors to measure gamma radiation levels at selected locations on the Oak Ridge Reservation. Monitoring using these instruments is directed toward sites where exposure rates are expected to fluctuate significantly over relative short periods and/or there is a potential for the accidental release of gamma emitting radiouclides. Data derived from the program, along with that generated by environmental dosimetry, is used to identify unplanned releases and assess the need and / or effectiveness of remedial activities.

In 2001, the gamma monitors were stationed at a background location (Fort Loudoun Dam) and four sites undergoing remediation. Three of these sites--the 3513 Waste Holding Basin, Corehole 8 Remedial Action, and the Molten Salt Reactor Experiment--are located at the Oak Ridge National Laboratory (ORNL). The forth site was located at the East Tennessee Technology Park (ETTP) inside the K-33 Process Building. The highest results recorded were at ORNL's Corehole 8 Remedial Action Project. At this site, unanticipated levels of transuranic wastes were encountered during the excavation of an underground storage tank and contaminated soils. Exposure rates at the site substantially decreased after the removal action was temporarily suspended and the excavation filled. Exposure rates measured at the 3513 Waste Holding Basin have decreased since 1999 as remediation of contaminated sediments in the basin has progressed. The exposure rates recorded at the Molten Salt Reactor in 2001 were consistent during the monitoring period (~90 µR/hr), except for several instances in May when the measurements exceeded 150 µR/hr. These excursions have been attributed to the removal of uranium laden charcoal from the reactor's filter bed. The exposure rates recorded at the K-33 Process Building were similar to the background measurements taken at the Fort Loudoun Dam.

Introduction

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division in association with its Ambient Gamma Radiation Monitoring Program has deployed continuously recording exposure rate monitors on the Oak Ridge Reservation (ORR) since 1996. While the environmental dosimeters used in the division's Ambient Monitoring Program provide the cumulative dose over the period monitored, the results can not account for the specific time, duration, and magnitude of fluctuations in the dose rates. Consequently, a series of small releases cannot be distinguished from a single large release, using the dosimeters alone. The division's continuous exposure rate monitors record gamma radiation levels at pre-set intervals over extended periods. This provides an exposure rate profile that can be correlated with changing environmental conditions.

The continuous gamma monitors have primarily been used to record exposure rates during remedial activities and supplement the integrated dose rates provided by the division's environmental dosimetry. In 2001, the locations monitored included three sites at the Oak Ridge

National Laboratory (ORNL) being addressed as removal/remedial actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a facility at the East Tennessee Technology Park (ETTP) undergoing clean-up as part of the Department of Energy (DOE) reindustrialization effort, and a background location in Loudon County.

Methods and Materials

The gamma exposure monitors used in the program are manufactured by Genitron Instruments and marketed under the trade name GammaTRACER®. Each unit contains two Geiger-Mueller tubes; a microprocessor controlled data logger, and lithium batteries. These components are sealed in a weather resistant case to protect them from the elements.

The gamma monitors have the capability to measure exposure rates from 1 μR/hr to 1 R/hr at predetermined intervals (one minute to two hours) over relatively long time periods (e.g., a year). The results reported are the average of the measurements recorded by the two Geiger Mueller detectors. (data for each detector can be accessed, if necessary). The data recorded by the instruments is downloaded using an infrared transceiver and computer software manufactured by Genitron.

Monitoring in the program focuses on the measurement of exposure rates under conditions where gamma emissions can be expected to fluctuate substantially over relatively short periods and/or there is a potential for the unplanned release of gamma emitting radionuclides to the environment.

Results and Discussion

In 2001, the gamma monitors were stationed at a background station (Fort Loudoun Dam) and four sites currently undergoing remediation. Three of these sites (the 3513 Waste Holding Basin, Corehole 8 Remedial Action, and the Molten Salt Reactor Experiment) are located at the Oak Ridge National Laboratory. The forth location was at the East Tennessee Technology Park inside the K-33 Process Building. This facility is undergoing cleanup in association with the DOE's reindustrialization program.

Fort Loudoun Dam Background Station: Background gamma exposure rates fluctuate over time due to various phenomena that alter the quantity of gamma emitting radionulides in the environment and/or the intensity of the radiation being released by these radionuclides. For example, the gamma exposure rate above soils saturated with water after a rain can be expected to be lower than that over dry soils, because the moisture attenuates radiation released by terrestrial radionuclides.

To better assess exposure rates measured on the reservation and the influence that natural conditions have on these rates, staff placed one of the division's continuous gamma monitors at Fort Loudoun Dam in Loudon County to collect background information. Figure 1 depicts the exposure rates measured at the background station from 03/24/99 to 12/31/01. During this period, exposure rates averaged 8.8 μR/hr and ranged from 7 μR/hr to 17 μR/hr. As might be expected, the highest rates recorded were during the dryer seasons (summer & fall) and the lower rates were reported during the wetter seasons (winter & spring).

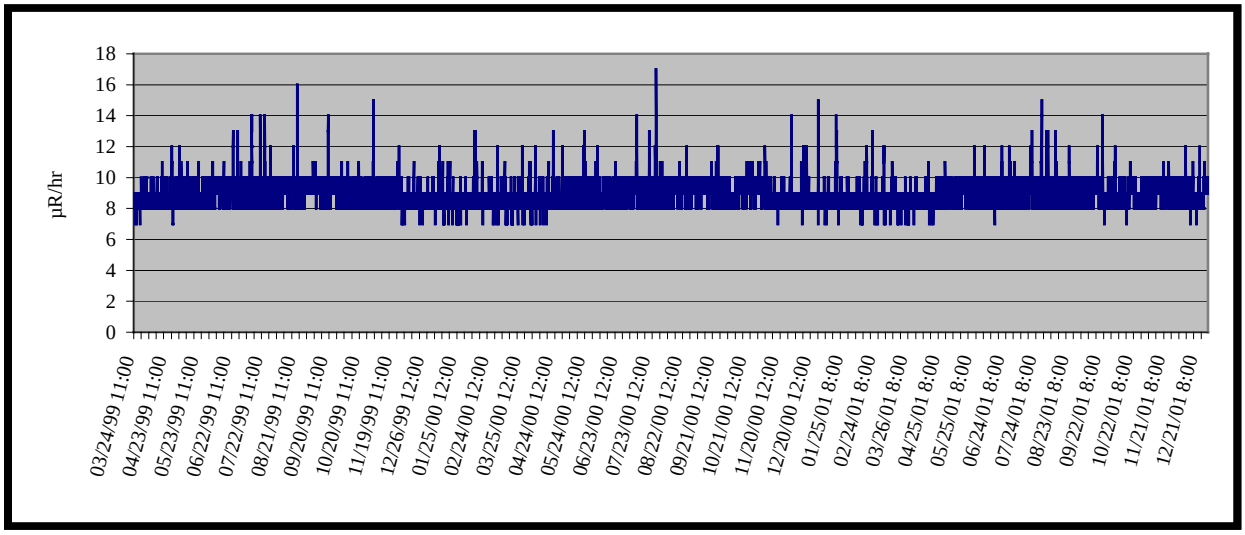
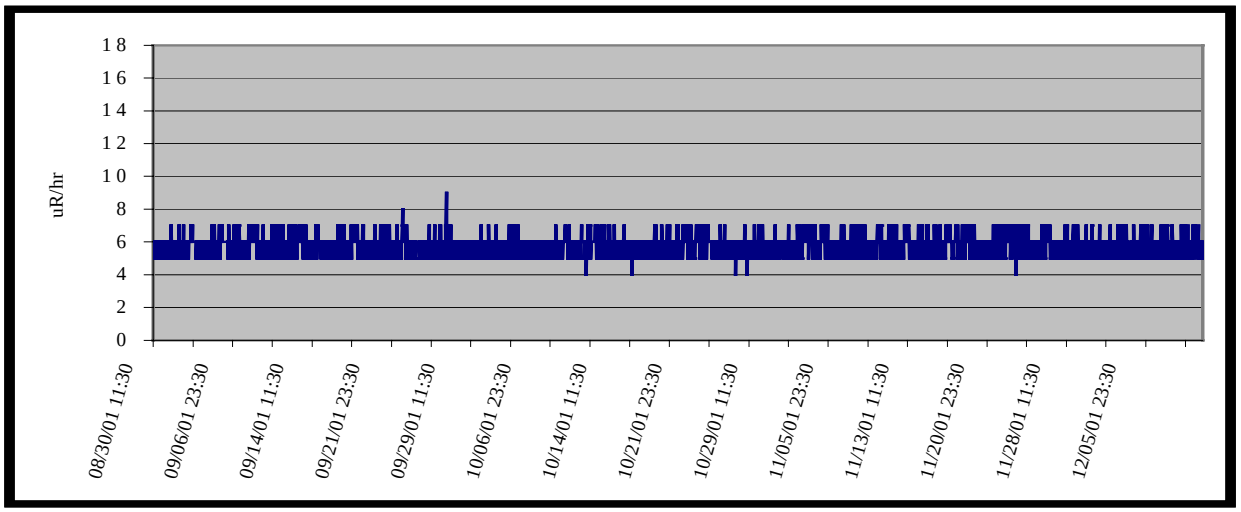


Figure 1: Results of Continuous Gamma Exposure Rate Monitoring at the Background Station located near Fort Loudoun Dam in Loudon County

The K-33 Process Building: The K-33 Process Building at ETTP housed the last and largest of the Oak Ridge Gaseous Diffusion Plant cascades used to enrich uranium. Currently, the building is undergoing clean-up activities in association with DOE's reindustrialization effort. Contaminants associated with the facility include uranium isotopes, technetium-99, and transuranic radionuclides. On 08/30/01, staff placed one of the gamma monitors on a wall opposite a large compactor used to compress wastes generated by the project. From 08/30/01 through 12/12/01, exposure rates measurements at the location averaged 5.5 µR/hr and ranged from 4 to 9 µR/hr (Figure 2), which is a little less than the measurements taken at the background station during the same period.

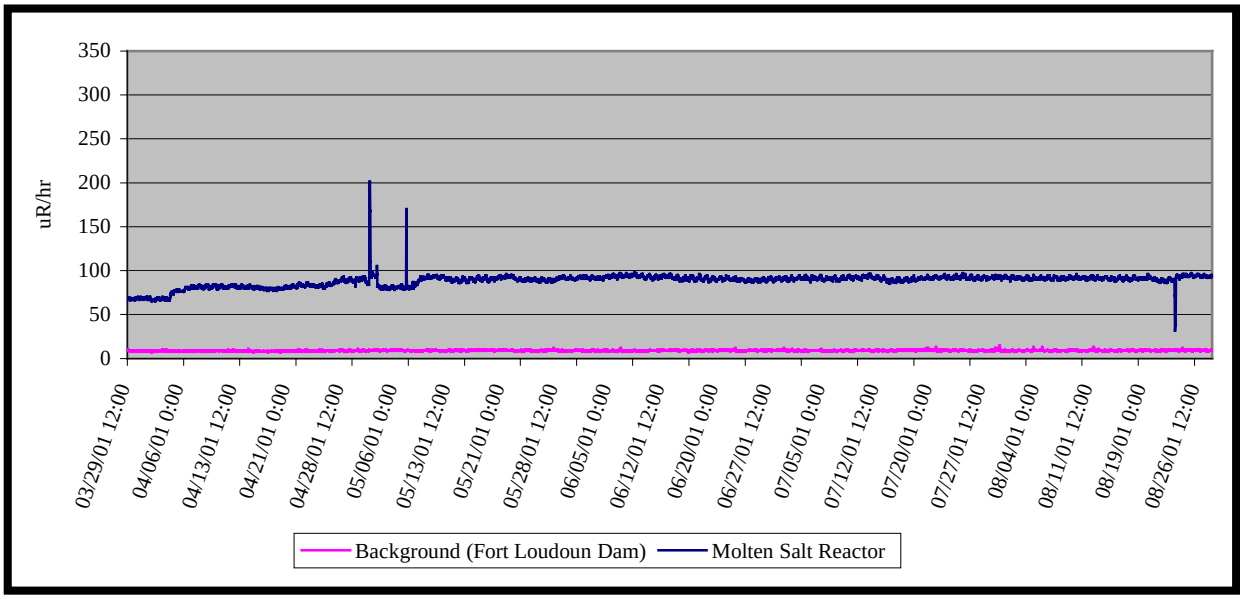


Note: The state limit for exposures to members of the public is 2000 µrem/hr (R = rem for gamma radiation). The annual dose limit for members of the public is 100,000 µrem/yr.

Figure 2: Results of Continuous Gamma Exposure Rate Monitoring at the K-33 Process Building

The Molten Salt Reactor Experiment (MSRE): The MSRE was designed to test the feasibility of producing nuclear power using Molten Salt Reactors. Located in ORNL's Melton Valley, the MSRE operated from 1965 to 1969. When the reactor was shut down, fuel containing uranium-235, uranium-233, and plutonium was drained into tanks at the site and solidified. In 1994, an inspection of the facility indicated uranium hexafluoride (UF_6) and fluorine gas generated during storage of the fuel had flowed through the off-gas piping system into various components of the reactor. These components included the charcoal filter bed, where uranium deposits were found to pose a threat of an accidental nuclear criticality. A time critical removal action was initiated in 1995 to reduce risks of nuclear criticality, exothermic chemical reactions, and accidental releases from the off-gas system (DOE, 2001).

Readings recorded at the MSRE site from 03/29/01 to 8/29/01 averaged 88 µR/hr and ranged from 32 to 201 µR/hr (Figure 3). For comparison, background readings during the period averaged 9.0 µR/hr and ranged from 7 to 17 µR/hr. The prominent peaks that can be observed in Figure 3 during May have been attributed to the removal from the facility of charcoal laden with uranium-233 and associated daughter products.



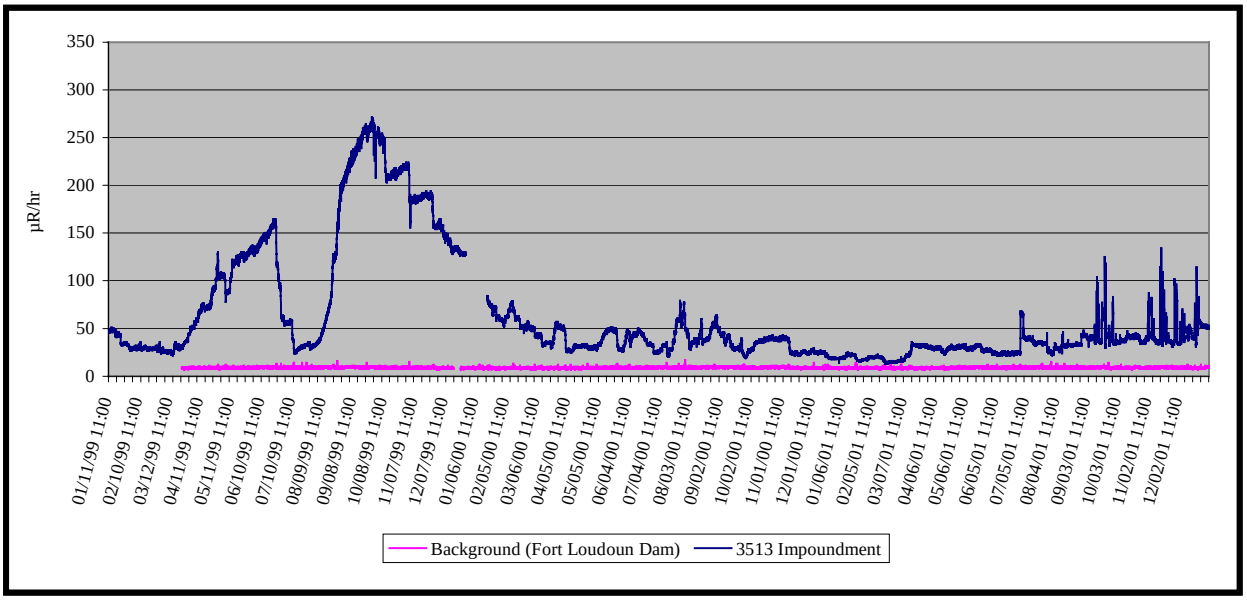
Note: The state limit for exposures to members of the public is 2000 µrem/hr (R = rem for gamma radiation). The annual dose limit for members of the public is 100,000 µrem/yr.

Figure 3: Results of Continuous Gamma Exposure Rate Monitoring at the Molten Salt Reactor Experiment Remedial Action and Background Measurements taken at Fort Loudoun Dam in Loudon County.

T*he 3513 Waste Holding Basin*: From 1944 to 1976, the 3513 Waste Holding Basin served as a settling pond for ORNL effluents prior to their release to White Oak Creek. Consequently, sediments at the bottom of the basin accumulated significant amounts of radioactive materials. These wastes include an estimated 200 curies of cesium-137 (Bechtel, 1992): the radionuclide primarily responsible for elevated gamma emissions measured at the basin. A CERCLA Record of Decision (signed September 24, 1997) provided for the removal and disposal of contaminated

sediments in the 3513 Impoundment and the adjacent 3524 Equalization Basin (which also received radioactive wastes, historically).

In order to measure the effectiveness of this action, division staff attached an exposure rate monitor to a tree located approximately 28 feet from eastern edge of the 3513 Impoundment in 1999. From 01/11/99 to 12/31/01 the exposure rates measured at the basin averaged 36.4 µR/hr and ranged from 13 to 271 µR/hr. Figure 4 plots the exposure rates recorded at 3513 during this period, along with background data collected at Fort Loudoun Dam.



Note: The state limit for exposures to members of the public is 2000 µrem/hr (R = rem for gamma radiation). The annual dose limit for members of the public is 100,000 µrem/yr.

Figure 4: Results of Continuous Gamma Exposure Rate Monitoring at the 3513 Waste Holding Basin and Background Measurements taken at Fort Loudoun Dam in Loudon County.

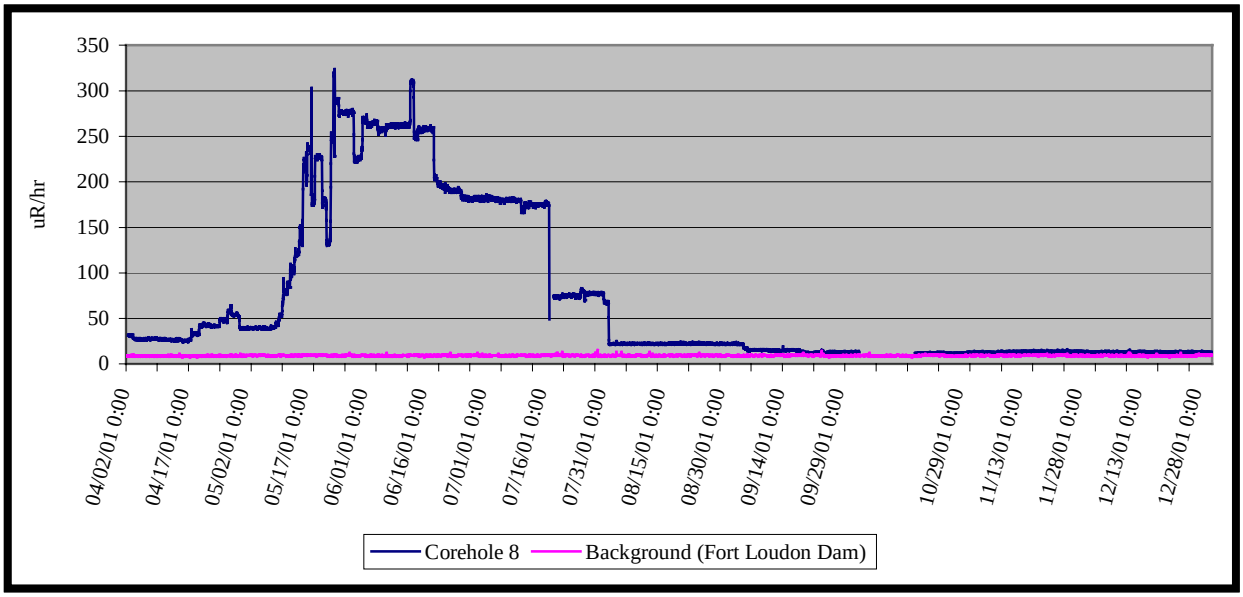
To a large degree, significant fluctuations in the exposure rates at the 3513 Waste Holding Basin can be attributed to changes in the water level in the impoundment. In this regard, water in the impoundment attenuates (shields) gamma radiation emitted by the wastes contained in the sediments. The increased water level during the wetter months and/or during storm events enhances this effect and provides shielding to previously exposed sediments at the basin perimeter, resulting in lower exposure rates. A significant increase in the exposure rates during August 1999 was due to the lowering of the water level in the basin to repair a seep that had been observed in the berm that separates the basin from White Oak Creek. During 1999, the exposure rates at the basin averaged 116 µR/hr and ranged from 22 to 272 µR/hr.

In the summer of 2000, DOE contractors began transferring sediments from the 3524 Equalization Basin to the 3513 Impoundment in preparation for their final removal and disposal. During this effort, the water level in the basin was maintained to reduce radiation emitted by the sediments and the potential for contaminants to becoming airborne. As a consequence, the exposure rates at 3513 decreased. In 2000, the exposure rates at the basin averaged 39.1 µR/hr and ranged from 18 µR/hr to 84 µR/hr.

In the summer/fall of 2001, DOE contractors began removing sediments from the 3513 Basin. Once removed, the sediments are dewatered, formed into bricks, and stored near the 3525 Equalization Basin. Periodic increases in the exposure rates during the last half of 2001 are an artifact of these activities. In 2001, the exposure rates at the basin averaged 33 µR/hr and ranged from 13 µR/hr to 134 µR/hr. The radiation associated with the site should continue to decrease with the completion of the project, which includes back-filling the basin and disposing of the contaminated sediments.

The Corehole 8 Removal Action: The North Tank Farm is located near the center of ORNL's main campus. In the past, a number of underground storage tanks were emplaced at this location to store and/or treat radioactive and hazardous wastes. In the 1990s, one of these tanks, W-1A was discovered to be the source of contaminants feeding the Corehole 8 groundwater plume. This plume covers a large area to the west of the site and associated contaminants are known to enter First Creek, where they are transported to White Oak Creek and the Clinch River. These contaminants include strontium-90, americium-241, plutonium-238, 239, 240, and curium-244 (Bechtel, 1992). In 1998, DOE proposed to remove W-1A and adjacent soils (which have developed into a secondary source of the contaminants feeding the plume). This removal action was scheduled to begin in 2001.

On 04/02/01, division staff secured one of the gamma monitors to a tree across from the North Tank Farm, approximately 75 feet from where Tank W-1A is located. This monitor is located next to a sidewalk used by pedestrian traffic to access ORNL's cafeteria and other local facilities. From 04/02/01 to 12/31/01, exposure rates at this location averaged 72 µR/hr and ranged from 11 to 324 µR/hr (Figure 5).



Note: The state limit for exposures to members of the public is 2000 µrem/hr (R = rem for gamma radiation). The annual dose limit for members of the public is 100,000 µrem/yr.

Figure 5: Results of Continuous Gamma Exposure Rate Monitoring at the Corehole 8 Remedial Action and Background Measurements taken at Fort Loudoun Dam in Loudon County.

The soils above subsurface contaminants shield radiation emitted by the materials beneath. Unless additional shielding is provided, it can be expected that exposure rates will increase as contaminants are uncovered and brought to the surface during remediation. In Figure 5, an increase can be observed during May and June when the tank and contaminated soils were uncovered in preparation for their removal. In this case, the contaminants included transuranic wastes that exhibited much higher radioactivity than had been anticipated by the DOE contractors hired to perform the action. As a consequence, the contractors replaced and covered the materials that had been excavated, until alternate methods can be developed to handle the wastes. As can be noted in Figure 5, the exposure rates subsequently decreased to near background levels at the monitoring location.

Conclusion

The use of continuous exposure rate monitors in conjunction with environmental dosimetery has proven to be a relatively economical and effective method of monitoring gamma radiation levels on the reservation. While environmental dosimetry provides an integrated dose level, the continuous exposure rate monitors are capable of recording an exposure rate profile that provides specific gamma radiation levels at relatively short intervals over extended periods of time. This capacity has proven valuable when trying to identify the source and duration of unplanned releases or correlate exposure rates with changing environmental conditions, such as those encountered during remedial activities.

From 1999 through 2001, the continuous gamma rate monitor placed at the background station exhibited fluctuations characteristic of the influence of natural phenomena. Lower exposure rates were recorded during the wetter seasons, when the higher moisture content of the soils and/or snow cover attenuate radiation emitted by terrestrial radionuclides. While fluctuations in gamma background measurements can be attributed to a number of variables, shielding of terrestrial gamma emissions by moisture in the soil appears to be a major factor affecting the exposure rates recorded.

The radiation shielding capacity of water was also evident in measurements taken at the 3513 Waste Holding Basin from 1999 through 2001. Water in the basin shielded gamma radiation being emitted by the radioactive contaminants in the basin sediments. When the water level was low, contaminated sediments at the basin perimeter were exposed resulting in higher exposure rates. As the water level rose, shielding was provided from radiation emitted by the previously exposed sediments and the exposure rates decreased. Exposure rates measured at the 3513 Impoundment substantially decreased in 2000, due to the water level being maintained during remedial activities. The exposure levels remained lower in 2001, but the removal, treatment, and storage of the contaminated sediments from the basin resulted in higher levels than recorded in 2000. These exposure rates should decrease with the removal of the sediments from the site and closure of the basin.

In addition to moisture, soils can be expected to shield radiation emitted by contaminants beneath the ground surface. The highest exposure rates measured in 2001 were in association with the excavation of an underground storage tank (W-1A) and contaminated soils feeding the Corehole 8 groundwater plume at ORNL. While the monitoring station was located approximately 75 feet from the excavation, exposure rates increased from approximately 30 μR/hr to 324 μR/hr as the tank and associated contaminants were uncovered. In this case,

contaminants included transuranic wastes that exhibited much higher radioactivity than had been anticipated. As a consequence, the materials excavated were replaced to lower the exposure rates, until alternate methods for handling the waste can be developed.

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Chapter 7 RADIOLOGICAL MONITORING

Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride (UF_6) Cylinder Yards at the East Tennessee Technology Park.

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Abstract

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (TDEC DOE-O) in cooperation with the Department of Energy (DOE) and the Bechtel Jacobs Company is conducting a radiation dose rate survey of the East Tennessee Technology Park's (ETTP) Uranium Hexafluoride (UF_6) cylinder storage yards. Dose rate measurements are taken at the boundary fence lines using Landauer® Luxel® optically stimulated luminescence (Aluminum Oxide) dosimeters. Monitoring of ambient gamma levels at the UF_6 cylinder storage yards began in April 1999, and has continued to date. The data gathered is being used to determine if areas monitored have exceeded state and/or federal regulatory limits for exposure to members of the public. This data is also being used to determine if environmental concerns are warranted and what, if any, remediation actions are necessary before this property is free released and/or prior to occupation by companies during the planned reindustrialization of the ETTP site. In this study period from January 2001, to January 2002, dose rates in excess of the 100-mrem/yr state/federal exposure limit were observed at all five of the monitored cylinder yards. Starting in the last quarter of 2000, an additional project was begun that involves obtaining specific location telemetry of each dosimeter by the use of a hand held GPS instrument. This specific location data, along with its corresponding radiological data, will be incorporated into the MapInfo computer program. When complete, the user will have the ability to locate an individual monitoring point and view its radiological history.

Introduction

During the development and operation of the gaseous diffusion uranium enrichment process, containers, support equipment, and support facilities were designed, constructed, and used to store, transport, and process the depleted UF_6. After a significant inventory was produced, outdoor storage facilities (i.e., cylinder yards) evolved. Today, the Bechtel Jacobs Company operates the six ETTP UF_6 cylinder storage yards for the DOE. They are used for the temporary and long-term storage of UF_6 cylinders. The goal of the DOE-O UF_6 cylinder yard dose assessment program is to evaluate the level at which the public is protected from radiation doses emitted from the cylinder yards. This is especially important since DOE's mission is the continual transformation of ETTP into a commercial industrial park.

Materials and Methods

Dosimeters measure the dose from exposure to gamma radiation over time. The division's cylinder yard monitoring is performed using one type of dosimeter, Aluminum Oxide. They are obtained from Landauer®, Inc., Glenwood, Illinois. Aluminum Oxide dosimeters (minimum reporting value of 1 mrem) are generally placed in areas where exposures are expected to be significantly higher than background. The dosimeters are collected by division staff and shipped to Landauer® for processing. To account for exposures that may be received in transit or storage, control dosimeters are included in each shipment from the Landauer® Company. The control

dosimeters are stored at the division office and returned to Landauer® with the field-deployed dosimeters for processing. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division offices (761 Emory Valley Road, Oak Ridge, Tennessee), is subtracted from the exposure reported for the field deployed dosimeters. Annually, the quarterly exposures (minus the exposure obtained from the control dosimeter) are summed for each location. The resultant annual dose is compared to the state/DOE primary dose limit for members of the public (100 mrem/yr exposure).

Discussion and Results

The Division's Ambient Gamma Radiation Monitoring program has determined that there is an elevated exposure potential to the public at all five of the monitored cylinder yards. At these yards, the total adjusted accumulated annual dose, as measured by dosimeter, has ranged from a low of below the minimum measurable quantity of 1 mrem at the K-1066-J yard to a high of 9004 mrem at the K-1066-E yard. Within this range, there are numerous elevated data points that are shown in tables 1-5. These results are compared with the state/DOE primary dose limit for members of the public (100 mrem/yr total exposure). The mapping and recording of dose rate data will ensure that workers/non-DOE workers under ETTP's reindustrialization plan and the public will be knowledgeable of and protected from the cylinder yard's radiation source.

The following ETTP cylinder yards under the dosimeter project are:
K-1066-K, K-1066-E, K-1066-J, K-1066-B, K-1066-L.

Current and future plans by ETTP to prepare cylinders for yard to yard movement and off-site shipment will necessitate "shuffling" cylinders between various yards. It is anticipated that the dose readings will change as these cylinders are sorted by size and content. K-1066-F yard is not being monitored due to the fact it does not have an outside perimeter fence that could be accessed by the public.

Table 1: Results from dosimeter's deployed at ETTP UF_6 Cylinder Yards.

K-1066-K Yard

	Period 1 (01/12/01 - 04/10/01) (88 Day Exposure)	**Period 2** (04/10/01 - 07/18/01) (99 Day Exposure)	**Period 3** (07/18/01 - 10/25/01) (99 Day Exposure)	**Period 4** (10/25/01- 01/28/02) (95 Day Exposure)	Total Accumulated Dose Equivalent: 381days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
1	45	55	43	46	189	181
2	262	227	251	421	1161	1112
3	914	642	365	700	2621	2511
4	1019	842	813	1686	4360	4177
5	819	807	297	493	2416	2315
6	973	883	382	424	2662	2550
7	436	424	339	320	1519	1455
8	764	914	786	528	2992	2866
9	943	1233	716	687	3579	3429
10	167	302	286	266	1021	978
11	141	200	191	162	694	665
12	347	447	409	378	1581	1515
13	1318	1494	1556	1532	5900	5652
14	1122	1410	1713	2021	6266	6003
15	1098	1377	1429	1474	5378	5152
16	889	1093	1359	1005	4346	4163
17	435	540	533	482	1990	1906
18	904	1151	1106	1024	4185	4009
19	1550	1912	1891	1703	7056	*6760*
20	1147	1513	1427	1253	5340	5116
21	140	175	145	140	600	575
22	408	482	464	388	1742	1669

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters.

M= Below minimum reportable quantity.

Table 2: Results from dosimeter's deployed at ETTP UF_6 Cylinder Yards.

K1066-E
Yard

Dosimeter Number	**Period 1** (01/12/01 - 04/10/01) (88 Day Exposure) Dosimeter Reading (mrem)	**Period 2** (04/10/01 - 07/18/01) (99 Day Exposure) Dosimeter Reading (mrem)	**Period 3** (07/18/01 - 10/25/01) (99 Day Exposure) Dosimeter Reading (mrem)	**Period 4** (10/25/01 – 01/25/02) (92 Day Exposure) Dosimeter Reading (mrem)	Total Accumulated Dose Equivalent: 378 days mrem	Total Adjusted Dose to 365 days mrem
23	562	757	806	655	2780	2684
24	424	634	767	770	2595	2506
25	1261	1479	1573	1399	5712	5516
26	1982	2720	2986	1637	9325	*9004*
27	1349	542	876	848	3615	3491
28	498	902	917	992	3309	3195
29	716	384	1090	1056	3246	3134
30	599	645	1149	1161	3554	3432
31	566	402	605	521	2094	2022
32	286	310	357	330	1283	1239
33	63	74	121	245	503	486
34	766	1015	1036	863	3680	3553
35	158	209	203	197	767	741
36	291	366	399	369	1425	1376
37	335	388	441	365	1529	1476
38	359	469	463	442	1733	1673
39	296	346	415	382	1439	1390
76	73	78	100	77	328	317
77	214	269	299	251	1033	997
78	109	130	158	141	538	519
79	325	229	317	290	1161	1121
80	175	229	415	372	1191	1150
81	186	185	451	413	1235	1193
82	193	260	435	392	1280	1236
83	150	161	247	238	796	769
84	123	159	196	185	663	640

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.
* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field deployed

dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters.
M= Below minimum reportable quantity.

Table 3: Results from dosimeter's deployed at ETTP UF_6 Cylinder Yards.

K1066-J
Yard

	Period 1 (01/10/01 - 04/12/01) (93 Day Exposure)	**Period 2** (04/12/01 - 07/20/01) (99 Day Exposure)	**Period 3** (07/20/01 - 10/24/01) (96 Day Exposure)	**Period 4** (10/24/01 - 01/25/02) (93 Day Exposure)	Total Accumulated Dose Equivalent: 381 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
40	M	3	M	1	4	4
41	M	1	3	M	4	4
42	M	M	3	M	3	3
43	9	4	2	M	15	14
44	13	11	6	M	30	29
45	16	12	19	7	54	52
46	27	22	16	4	69	66
47	35	32	34	20	121	116
48	62	74	71	61	268	257
49	227	153	147	131	658	*630*
50	266	129	131	90	616	590
51	337	47	52	30	466	446
52	558	19	22	16	615	589
53	13	10	8	6	37	35
54	6	7	6	2	21	20
55	3	6	M	1	10	10
85	M	1	3	M	4	4
86	M	2	3	M	5	5
87	2	5	4	M	11	11
88	14	11	7	5	37	35
89	18	15	11	7	51	49
90	23	18	14	9	64	61
91	27	27	24	18	96	92
92	26	28	22	17	93	89

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

*To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background

radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters.
M= Below minimum reportable quantity.

Table 4: Results from dosimeter's deployed at ETTP UF_6 Cylinder Yards.

K1066-B Yard

	Period 1 (01/12/01 - 04/11/01) (89 Day Exposure)	**Period 2** (04/11/01 - 07/25/01) (106 Day Exposure)	**Period 3** (07/25/01 - 10/23/01) (90 Day Exposure)	**Period 4** (10/23/01- 01/22/02) (91 Day Exposure)	Total Accumulated Dose Equivalent: 376 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
56	14	25	26	15	80	78
57	48	62	52	41	203	197
58	75	58	59	48	240	233
59	58	83	70	63	274	*266*
60	28	49	43	34	154	149
61	42	65	53	41	201	195
62	37	64	53	41	195	189
63	21	51	40	35	147	143
64	9	42	29	27	107	104
65	9	23	19	15	66	64
66	4	17	24	10	55	53
67	5	14	9	7	35	34
93	16	32	28	21	97	94
94	17	46	46	35	144	140
95	27	54	46	38	165	160
96	33	60	52	38	183	178
97	5	14	12	9	40	39
98	4	12	7	4	27	26
99	3	13	10	4	30	29
100	5	8	10	5	28	27
101	*	11	10	8	29	28
102	21	32	27	21	101	98
103	6	10	12	5	33	32

* Dosimeter lost by Landauer in processing

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

*To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background

radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters.
M= Below minimum reportable quantity.

Table 5: Results from dosimeter's deployed at ETTP UF_6 Cylinder Yards.

K1066-L
Yard

	Period 1 (01/10/01 - 04/12/01) (93 Day Exposure)	**Period 2** (04/12/01 - 07/20/01) (99 Day Exposure)	**Period 3** (07/20/01 - 10/24/01) (96 Day Exposure)	**Period 4** (10/24/01- 01/25/02) (93 Day Exposure)	Total Accumulated Dose Equivalent: 381 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
68	52	56	53	45	206	197
69	52	62	56	48	218	209
70	50	62	65	48	225	216
71	1239	1369	1301	1358	5267	5046
72	2006	2254	2188	2136	8584	8224
73	1874	2317	2477	2366	9034	*8655*
74	1350	1641	1411	1261	5663	5425
75	901	1022	966	907	3796	3637

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

*To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters.

M= Below minimum reportable quantity.

Conclusions

The data are showing elevated readings at all five cylinder yards. These annual doses are in excess of the state/DOE primary dose limit for members of the public where the public has access. The yards may also produce ten or fifteen percent additional mrems in neutron as well as gamma doses. Neutron dosimetry is being gathered in another division program.

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